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ABSTRACT

This teacher's guide contains parts three and four of the four-part first year Portland Project, a three-year secondary integrated science curriculum sequence. Part three of the guide deals with topics such as the cell, reproduction, embryology, genetics, genetic diseases, genetics and change, populations, effects of density on populations, ecosystems, and communities. Part four deals with related topics. After studying about ecosystems in general terms, the emphasis is shifted to studying about the harmful effects of human activities in upsetting the balance of ecosystems. Topics include water pollution, air quality, and effects of air pollution. In both parts, laboratory exercises are suggested and lengthy lists of supplementary materials are included. Notes for the teacher, examples of data, and problem calculations are included. (SL)

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parts three and four of an integrated science sequence

D. Wilson

MICE AND MEN
ENVIRONMENTAL BALANCE

YEAR ONE TEACHER GUIDE

SE 021 560

TEACHER'S GUIDE

MICE AND MEN

AN INTEGRATED SCIENCE SEQUENCE

1970 EDITION

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MICE AND MEN

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MICE AND MEN

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Dedication

This volume is dedicated to the memory of Vernon Cheldelin under whose guidance and leadership integration of the sciences for Oregon secondary school youth was begun in 1963.

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Chapter I: REPRODUCTION AND DEVELOPMENT

A. - THE CELL

The process of observation and data recording which you have performed has historical significance dating back to the early scientific philosophers. Although we may look upon their methods with disdain and amusement, we must remember that they provided the foundation upon which we stand in our search for scientific truths today. In fact we have not yet brought all of their hypotheses into the realm of scientific laws. We observe mice reproducing and imagine we know the natural process which has taken place. If we truly did, couldn't we create mice?

The process which most clearly distinguishes the living from the non-living is reproduction. Although other characteristics are essential for survival of the individual organism, reproduction's sole purpose is the continuation of the species. Life has the capacity to give rise to new life.

Reproduction may involve one or more parents in its process. Sexual reproduction involves the fusion of sex cells from two parents. In

Reference Books for Teachers:

Biological Science,
Keeton; Norton Company

Biology,
C.A. Villee; Saunders Co.

Life,
G.G. Simpson; Harcourt, Brace and World

The Science of Biology,
Weisz; McGraw-Hill

Animals Without Backbones,
R. Buchsbaum; University of Chicago Press

Botany,
C.L. Wilson and W.E. Loomis; Holt, Rinehart, and Winston

Molecules to Man,
BSCS; Houghton Mifflin Co.

An Inquiry Into Life,
BSCS; Harcourt, Brace & World

High School Biology,
BSCS; Rand McNally & Co.

The Cell,
Life Nature Series
"The Cell," Scientific American,
Sept. 1961

The concepts of cell anatomy and function and the cell as the functional unit are presented through the process of cellular reproduction. The skills of microscope use are introduced since the students need to use microscopes again later in the unit.

Chapter V section C.2 contains instructions for student projects related to communities. In order to allow adequate time for student investigation you should EXAMINE THE MATERIAL NOW and decide when they must be started.

Materials and Equipment:

- *Microscope*
- *Slides, coverslips*
- *Scissors, forceps*
- *Newsprint*
- *Colored magazine illustrations*
- *Old nylon stocking*
- *Ruler*

The concepts of "cell anatomy and function" and "the cell as the functional unit" are presented through the process of cellular reproduction. The skills of microscope use are introduced at this point. Students need them now and later in the unit.

this way, living things receive new combinations of characteristics that may enable them to remain in adjustment with the environment. A type of reproduction thought to be more primitive is asexual reproduction. In this process there is duplication of the parent type with little or no variation.

To consider how organisms reproduce, we must go to the basic unit of life, the cell. We must find how the cell may function not only as a minute organism but also as a part of a very complex organism.

A.1 - Experiment: USING THE MICROSCOPE

Your compound microscope is an expensive instrument. It will serve you well, but it requires careful treatment. Please follow these rules:

1. Carry the microscope with two hands -- one on the arm of the instrument, the other under the base. It will not be jarred loose or slip from your hands in this position.

2. Carefully place the instrument on a table. Always keep it away from the edge. It will not tip off or be knocked off as easily.

3. Keep the lenses of the microscope clean, using only the special lens tissue provided; never use your handkerchief, any item

of clothing, or tissue paper. Finely ground lenses such as these may be marred with coarse material.

4. If something appears to be wrong with your microscope at the beginning of the laboratory period, notify the instructor immediately. Never attempt to clean the inside of a lens or make minor repairs on the microscope. A technician is trained to do this.

5. Always focus up from the slide, beginning with low power. You want to focus to the slide, not through it.

6. Always use a coverslip with wet mounts. A wet lens will blur the image.

7. Always rotate the low power objective into place over the stage and turn the coarse adjustment down before putting your microscope away. The microscope will fit in its storage space and be ready for the next student to use.

Obtain the compound monocular microscope assigned to you and place it gently on your desk. Although you may have used microscopes before, further advice and practice in the use of this instrument will increase your skill as a microscopist.

Inspect the microscope carefully. Your teacher will review the parts of the microscope.

It is recommended that the teacher use part of a period as a prelab in which rules for use of the microscope and the nomenclature of the microscope are discussed. Emphasis may be given to movable parts and those which may fall out or be removed with improper use. An entire lab period is required for the student to carry out Experiment A.

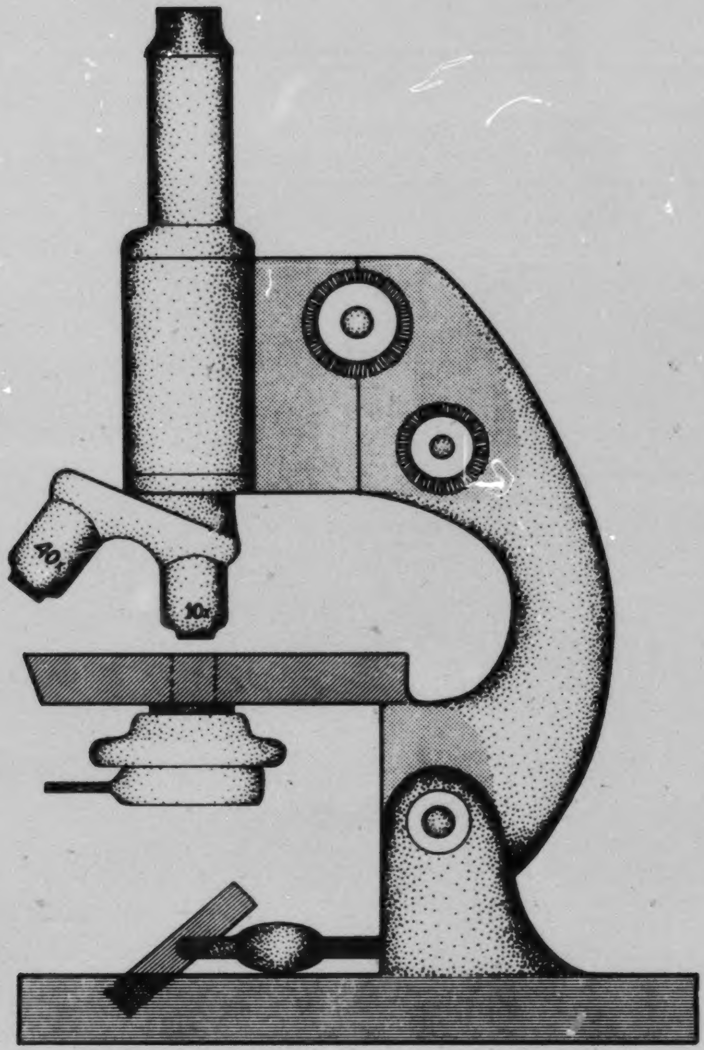


Figure A.1

Locate these parts on your microscope and record the names on the illustration (Figure A.1). In particular identify the ocular (eyepiece), body tube, nosepiece, objectives, focusing knob, fine adjustment focusing knob, arm, and base.

Be sure that your microscope is clean. Look through each objective and adjust the mirror and diaphragm for maximum illumination. If spots are viewed through all objectives, clean the ocular, stage, and mirror. If spots are seen only through one objective, clean that objective only. Wipe the objectives in one direction rather than in a circular motion to avoid scratching the lens.

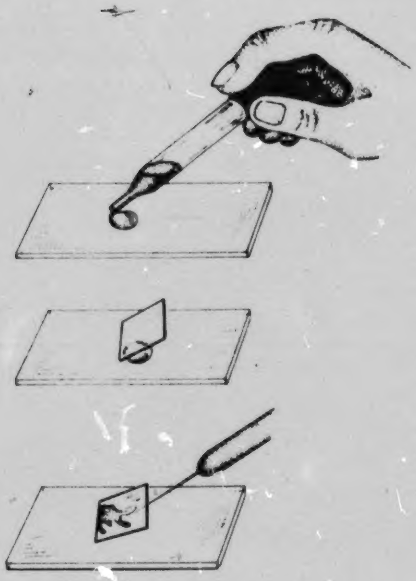
It should be obvious that the purpose of the microscope is to give a magnified image of the object you are viewing. To emphasize this capability and gain perspective of the actual object compared to the image we will consider the depth of field and diameter of each objective.

Explain the nature of the parfocal lenses.

Students who wear glasses should be encouraged to remove them when using the microscope.

Specific mention should be made that both eyes are kept open when using the microscope to prevent eyestrain.

From a section of newspaper on which the small letter "e" appears cut a piece about 1 cm square. Place the square on the slide so the letter "e" is right side up. Place a drop of water on the paper and allow it to soak in. Hold a coverslip at a 45 degree angle in contact with



the drop of water. Drop the coverslip into position on the paper. Bubbles may be removed by gently tapping the coverslip. You have now prepared a "wet mount." Draw the letter "e" as it appears on the stage of the microscope. Observing the letter "e" under low power, make a second drawing showing how it appears through the microscope. How do you account for this observation?

Next cut a section 1 cm square from a colored page of a magazine furnished by your teacher. Place the section on a slide and observe under medium and high power. Count the dots across the diameter of both the low and high power fields. Do you detect any differences?

A quality print such as that used in Scientific American, Nature, Atlantic, etc. is required to see the printed dots.

Cut a section of nylon hose one cm square. Place the section on a slide and add a coverslip. Observe the section under low power. What effect does the fine adjustment have on the image? Rotate the medium power objective into position. What effect does this have on the image size? Does fine adjustment produce a greater or lesser effect than that observed with low power? Carefully rotate the nosepiece to high power. Many coverslips are broken in this movement by the careless student. You will find it helpful to view the rotation from the side at stage level to

Less depth of field at higher power.

Check high power for clearance with nylon.

Here the teacher may use the students' observations to explain the nature of parfocal lenses.

see how close you are coming to the slide. Observe the nylon and again consider the effect on the size and depth of the image.

The depth of field, or extent to which you can look into an object, will be an important consideration when you are looking for structures in a cell. The notches on the knob of the fine adjustment may be used as a scale to determine the depth of field. With thin strips of masking tape, make a mark on the arm of the microscope and on one notch of the fine adjustment knob. What is the depth of the nylon in notches for low, medium, and high power? What would you guess to be the reason for any difference in depth of field for the three objectives?

Depth of field may also be illustrated with three thicknesses of colored thread (commercially prepared slides available) or using two letter "e's" offset and separated by a coverslip.

It is important to know the size of the field when we try to determine the actual size of an object we are viewing. Cut three pieces of graph paper three centimeters square. Label one low power, the second medium power, and the third high power. Next draw a circle that you believe represents the actual size of the field observed under each of these powers. Now test your perception by observing each circle under the corresponding power. How many times must you modify the size of the circles? When your circle fits the area of the field for the objective, measure its diameter and record it.

The graph paper should have as fine a grid as possible.

You now have a reference for comparing the actual size and the drawing size. Each drawing of things seen through the microscope must be labeled with the magnification. Example: The low power field may be 2 mm in diameter. If your drawing shows a field which measures 40 mm, your drawing would be labeled 20X, signifying that it is 20 times larger than the actual object.

The area is magnified 20^2 or 400.

We are now ready to use our acquired skills to look at some cells.

A.2 - CELLS OF PLANTS AND ANIMALS

TEACHERS: Read note at beginning of Section C, Reproduction, with instructions to prepare material for that lab ahead of time.

Although cells show great diversity in form and function, all cells are built to a fundamental design and share certain common features. From observations made in the following investigation it is possible to begin to build a model of a "typical" cell.

A.2.a - Experiment: ONION EPIDERMIS

Materials and Equipment:

- *Microscope*
- *Slides, coverslips*
- *Onion*
- *Iodine*

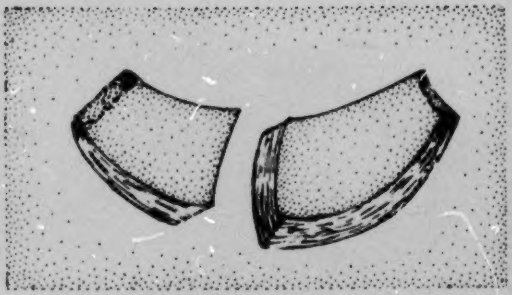
For part b add:

- *Toothpicks*
- *Methylene blue*

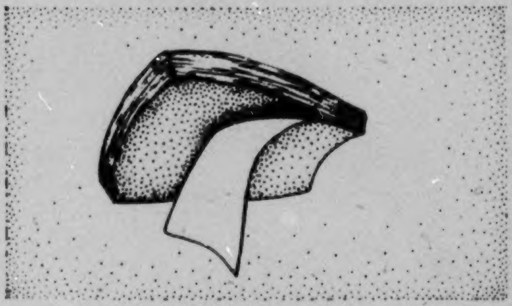
Cut an onion bulb into quarters. Observe that the onion is made up of layers.

Take one layer and hold it so that the concave side faces you. By snapping it backwards, a paper thin epidermis is usually seen as a ragged edge on the broken layer.

Using forceps remove a small piece of the epidermis and place it in a drop of water on a slide. Be sure that the epidermis is flattened.



Draw a coverslip across the slide to the drop of water and drop it onto the epidermis section.



Examine this wet mount under low power of your microscope. Adjust the diaphragm for best contrast. Examine the structure of the cell. Using the fine adjustment, explore the content of one cell. Make a drawing showing the cell as you see it.

Examine the cells under high power. With good contrast the separation between cells may be seen as a cell wall (a non-living structure). Immediately inside the cell wall is the cell membrane which encloses the cytoplasm. The cell membrane is about .01 micron thick and can only be seen with the electron microscope. What is observed with the light microscope is a much thicker layer of polysaccharides or carbohydrates.

A good extension for the plant cell material would be to observe some highly pigmented cells (Elodea leaf or flower petal epidermis) in a very salty solution; the difference between cell walls and cell membranes should be easy to see.

Staining will produce greater contrast in the internal structures. Prepare a second slide as you did the first, but add one drop of iodine to the drop of water before putting the onion epidermis in place.

Staining will only take a matter of minutes. On low power, a nucleus (plural nuclei) will appear as a golden body within the cytoplasm.

Observe the stained epidermis section under both the low and the high power objective.

Draw three or four of the epidermal cells. In one cell draw and label those structures that you were able to observe with your microscope.

A.2.b - Experiment: HUMAN EPITHELIUM

With the broad end of a toothpick gently scrape the inside of your cheek.

Stir the scrapings into one drop of water mixed with one drop of methylene blue on a slide.

Apply the coverslip and observe the slide under low power. The cells will be found in irregular clusters. Select one cluster to observe under high power.

Cell structure functions are well discussed in the references. The Upjohn book listed on page 1 is very good.

Draw three or four of these epithelial cells and in one cell draw and label those structures that you observe.

Did you observe a cell wall?

No cell wall is seen in animal cells.

A comparison of the onion and mouth cells shows the cell wall to be a primary difference between plant and animal cells. What is the function of the cell wall?

For support and some conduction.

Both of the cells observed may seem simple in their structure, but as we continue to observe the things that they do, their complexity becomes more impressive.

On the basis of your observations, draw and label your example of a simple cell. Suggest a function for each labeled structure.

A.3 - UNICELLULAR ORGANISMS

The first two cells you observed were units within a living organism. They carried out only a small part of the total activity of the organism. Next you will observe a microscopic, one-celled organism that carries out all life activities by itself.

A.3.a - Experiment: UNICELLULAR LIVING ORGANISMS

Place a ring (about one centimeter in diameter) of methyl cellulose on a slide. Place a drop of Paramecium culture into the ring.

Apply a coverslip and observe under low power.

Make a drawing of the paramecium showing its shape and structure, and the direction of any movement that you actually observe. Observe under high power and guess the function of the structures that you see within the paramecium.

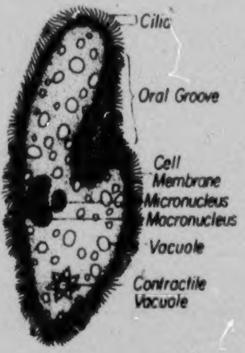
A model cell should include a cell wall, a nucleus, and cytoplasm. The cell membrane is implied but not observed.

Invitation to Inquiry #1 and #2 in Biology Teachers Handbook, Schwab; John Wiley and Sons, Inc.

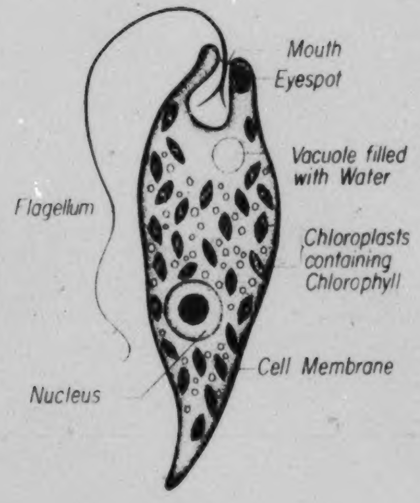
Materials and Equipment

- *microscopes*
- *slides*
- *coverslips*
- *methyl cellulose*
- *Paramecia*
- *Euglena*

Reference: Animals Without Backbones by R. Buchsbaum; University of Chicago Press.



Structures that may be seen in the paramecium:
- *Pelliele*
- *Nuclei (micro & macro)*
- *Contractile vacuole*
- *Oral groove*
- *Food vacuoles*
- *Cilia - under dark field*


Mouth
Eyespot
Vacuole filled with Water
Flagellum
Chloroplasts containing Chlorophyll
Cell Membrane
Nucleus

Euglena

Structures that may be seen in the Euglena:
- *Pellicle*
- *Nucleus*
- *Chloroplast*
- *Flagellum*
- *Eye spot*
- *Granules of food reserve*

Would you say that the paramecium is a simple cell? Why?

If there were any structures that you could not guess a function for, call them to the attention of your teacher.

On a second slide place a ring (about one centimeter in diameter) of methyl cellulose and within the ring place a drop of Euglena culture.

Apply a coverslip and observe under low power.

Observe under high power and guess the function of the structures within the Euglena.

One of the structures that you see will be green granules called chloroplasts. You should also observe a red spot (light sensitive area) near one end of the Euglena.

Make a drawing of the Euglena showing the shape of this single-celled organism and the structures which are found within.

Again call to the attention of your teacher any structure for which you cannot guess a function.

In light of the additional observations you have made, discuss with your classmates the significant changes, if any, which need to be made in the model cell you have constructed in experiments A.2.a and b. Can the cell model be expanded to include those structures found in a more complex cell? Try modifying the original cell model to include those structures observed in today's investigation.

"Typical Cell"

cell membrane (implied)
nucleus
cytoplasm
vacuoles

The point should be made by the teacher that cell walls, chloroplasts, eye spots, cilia, and flagella are not universal.

B. - OBSERVATIONS BY OTHERS

You have observed a variety of cells and have constructed a cell model. Although you may question your accuracy, information was acquired in the same manner by those who have found out all we know about the cell. It is now appropriate to read about the cell as a structure seen by trained observers with equipment more sophisticated than ours. This will enable us to complete the cell model and more nearly to understand the many functions of the cell.

A large amount of reference material is available about the cell. Our primary concern is those structures and functions that are useful in explaining the cell's role in the reproduction of an organism.

The Cell, Upjohn Co.
Cell, American Publications
The Cell, Life Nature Series
"The Cell", *Scientific American*, Sept. 1959.

Complete your cell model and the way it reproduces itself on the basis of observations and reference materials.

B.1 - THE MODEL CELL

You have constructed a cell model and have seen the structures and functions that others have observed. At this time a review is in order so that you may "nail down" any factor of cell organization that is not clear to you.

B.2 - HISTORICAL REFERENCES

A brief look at the historical inquiry into the nature of the cell may help us appreciate how scientific knowledge has been acquired.

Various members of the class will report on the significant contributions made to cellular knowledge by Robert Hooke, Hugo Mohl, M. J. Schleiden, Theodore Schwann, Rudolf Virchow, and August Weismann.

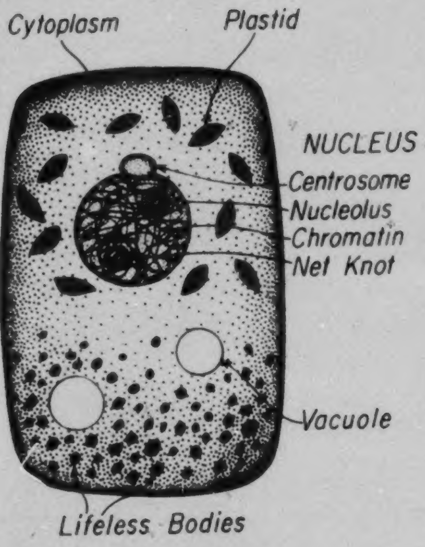
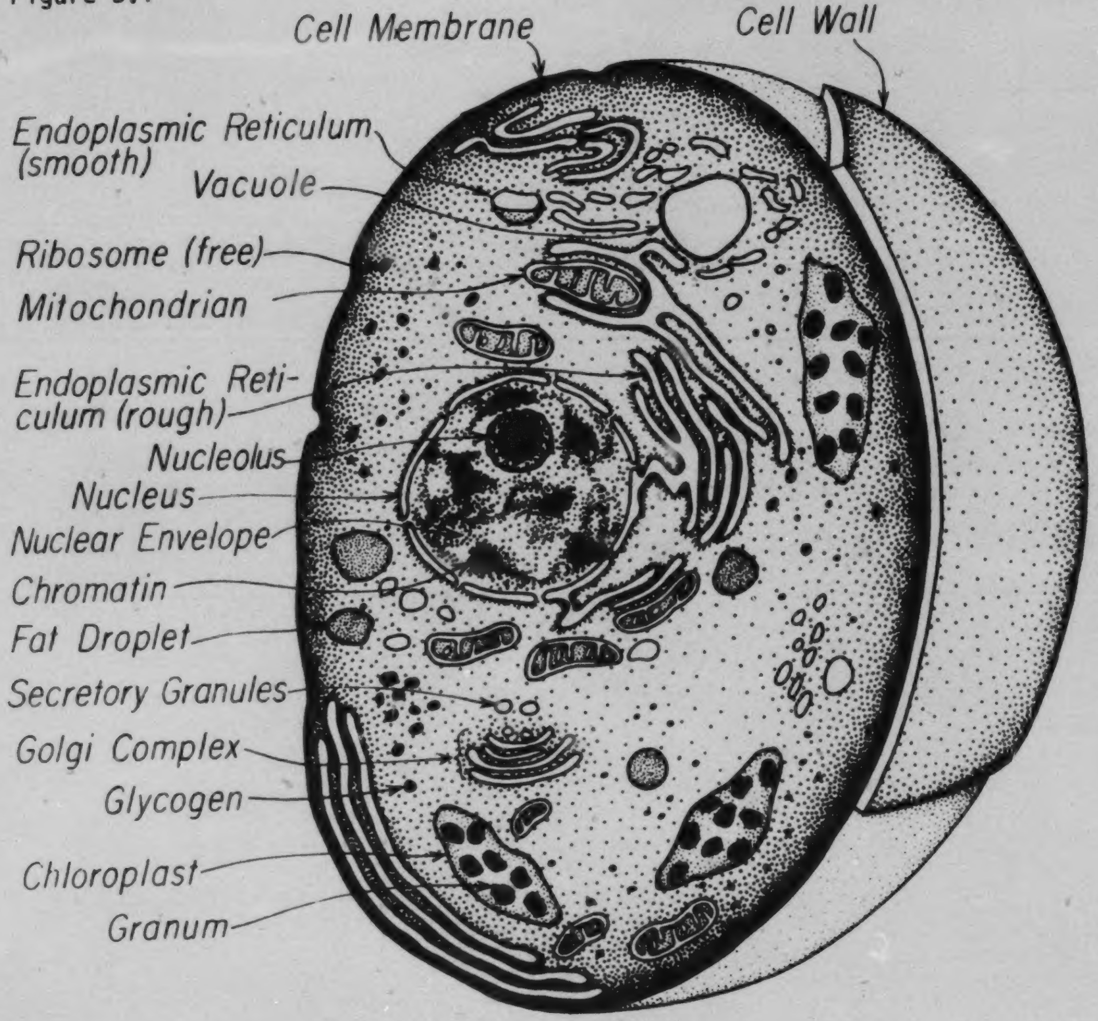

Cytoplasm
Plastid
NUCLEUS:
Centrosome
Nucleolus
Chromatin
Net Knot
Vacuole
Lifeless Bodies

Figure B.1

Figure B.2


Cell Membrane
Cell Wall
Endoplasmic Reticulum (smooth)
Vacuole
Ribosome (free)
Mitochondrian
Endoplasmic Reticulum (rough)
Nucleolus
Nucleus
Nuclear Envelope
Chromatin
Fat Droplet
Secretory Granules
Golgi Complex
Glycogen
Chloroplast
Granum

C. - REPRODUCTION

The survival of each species of plant and animal requires that new individuals replace those eliminated by disease, predators, or old age. The actual process involved varies tremendously from one species to another, but basic types of reproduction, asexual and sexual, can be distinguished. Asexual reproduction involves only one parent which splits, buds, or fragments to produce two or more offspring, identical to the parent. Sexual reproduction involves two parents which each contribute a specialized cell (sperm or egg) which fuse to form the fertilized egg (zygote). The biological advantage of sexual reproduction is that it permits variation through recombination of hereditary characteristics of both parents, resulting in offspring which may be better able to survive than either parent.

The cell, basic to life and therefore to reproduction, may divide in two ways. The most common type of cell division is called mitosis. The specialized cell which must be formed for sexual reproduction to occur is called a gamete. The process of reduction division by which it is formed is called meiosis.

Three days prior to the investigation of mitosis, set up six small onions or 48 hours prior, the sections from a clove of garlic per class. (Probably more than you will need per class, but it pays to have extra for those students who wish to try again. An average of one slide in five will show good mitotic figures.) The bottom of the onion or garlic section is suspended in a vessel of water (beaker or baby food jar) with tooth picks inserted into the bulb to hold it at a level where the water covers one-half of the bulb.

The prepared slides may be used by those students who become discouraged with their slides which do not show mitotic figures.

Onions prepared this way tend to show unison mitotic divisions. Most figures are obtained at root tip at 11 a.m. and 11 p.m. This appears to be a response to light. It is not known to us whether or not this timing holds true for garlic.

You may choose to run C.1 and C.2 at the same time.

C.1 - Experiment: MITOSIS IN THE ONION ROOT TIP

We may look at cell division as a characteristic of the cell. Again, we may consider cell division as a type of asexual reproduction.

Cut an onion root 1 cm from the tip and place it in 1M HCl. Let the tip soak for five minutes while you obtain a clean slide, coverslip, acetocarmine stain, and a razor blade. When the tip has soaked five minutes, place it on a clean slide in one drop of acetocarmine stain. Macerate the root tip in the stain by chopping vigorously with the razor blade until a pulp is made of the root tip. Apply a coverslip. Fold a section of paper toweling into a 3 x 5 rectangle to act as a cushion for squashing. Turn the slide over, coverslip down, and place it in the center of the cushion. Place the thumbs tip to tip parallel with the slide and press down to squash the root tip. Place the slide on the stage of the microscope and observe under low power. Find the area of the root just above the rounded tip where the most rapid cell division occurs. Examine under high power. If you have been careful in your technique and the root tip is at the proper stage, you should be able to locate all of the stages described as landmarks in the sequential process of mitosis.

Materials and Equipment

- *Six onions or one large garlic bulb per class*
- *Fresh acetocarmine stain*
- *Rusty razor blades*
- *1 slide and coverslip per student*
- *Paper towels*
- *Syracuse (or similar) dish to soak root tip in HCl*
- *Forceps*

1 liter of 1 molar HCl is made by pouring 42.8 ml. of conc. HCl into enough water to make 1 liter.

The film, "Mitosis," EBF (24 minutes) may be shown before the experiment.

The film loop, Squash and Smear Technique, may be used for introduction.

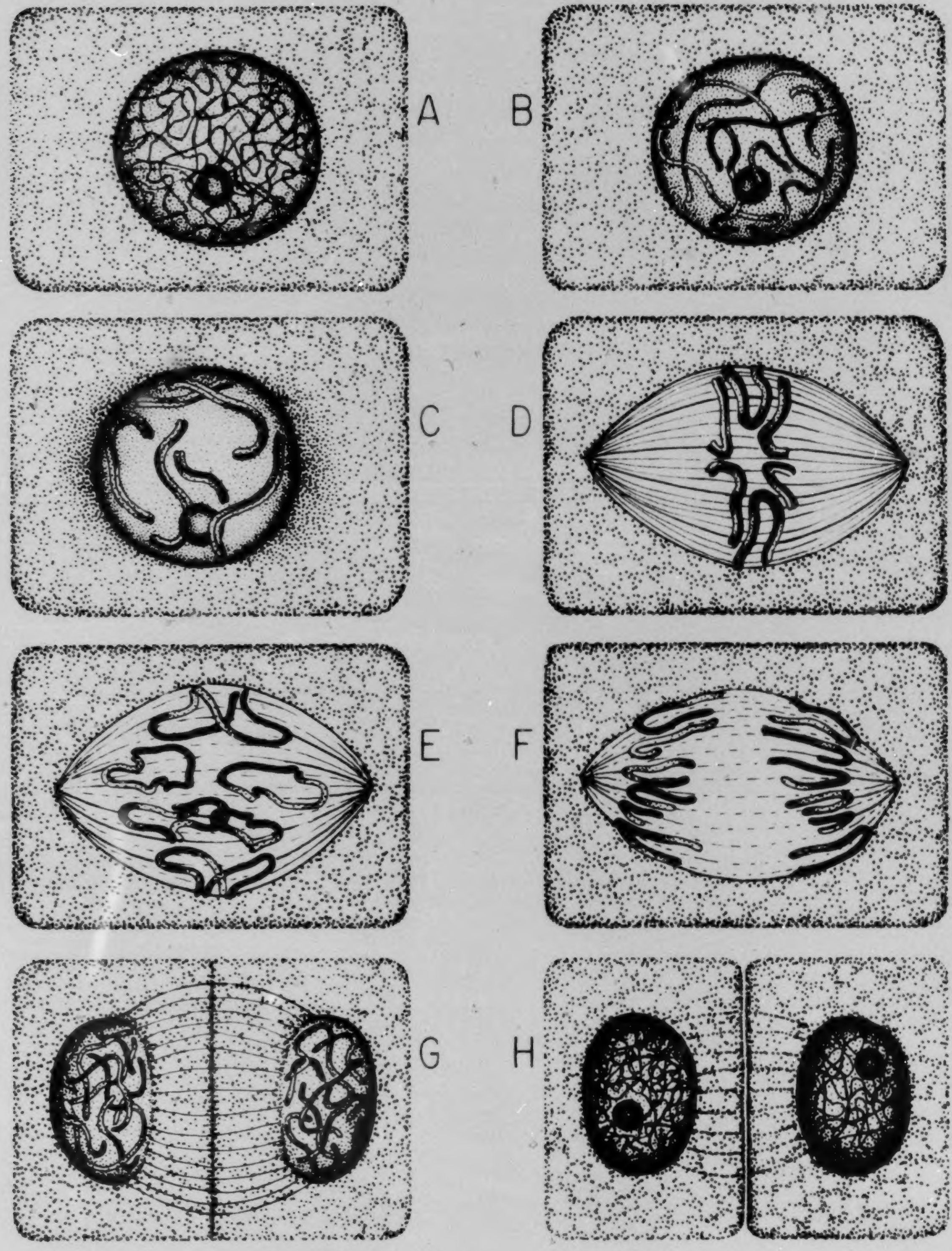


Figure C.1

The landmark titles for given arrangements of chromosomes are as follows:

1st Stage: (Interphase)	Cell and nucleus intact. No apparent activity.
2nd Stage: (Prophase)	Nuclear membrane has disappeared; chromosomes have replicated, shortened, and thickened and are now visible as thread-like structures in the cytoplasm.
3rd Stage: (Metaphase)	The chromosomes lie in a vertical plane equidistant between the two sides.
4th Stage: (Anaphase)	The chromosome pairs have split apart and are moving toward the sides.
5th Stage: (Telophase)	Formation of a cell plate takes place. The split chromosomes arrive at each side and begin to elongate and become obscure. The nuclear membrane reappears and with reorientation within the cytoplasm the cell division is complete, resulting in two identical daughter cells.

Do not require memorization of the vocabulary.

An 8mm film loop, "Mitosis - Pollen Cells in a Blood Lily," may be shown with the experiment.

If you have been unsuccessful in your first attempt at this squash technique, you are urged to try again.

In your own words construct a sequential description of the activities of one chromosome as it undergoes mitosis.

C.2 - ASEXUAL REPRODUCTION IN PARAMECIA

Some organisms are capable of reproducing both sexually and asexually. Such an organism is Paramecium, which you observed earlier.

Paramecia reproduce asexually by means of a process called fission. This phenomenon can be studied easily by observing a prepared slide of paramecia made from a population which was reproducing rapidly.

C.2.a - Experiment: PARAMECIUM FISSION

Obtain a prepared slide from your teacher and observe under the microscope. Locate a specimen which appears to be dividing into two parts. Make an outline sketch of the entire organism. Paramecia are unique in that the nuclear material is segregated into a kidney-shaped macronucleus and one or more small spherical micronuclei rather than contained in just one typical single nucleus. Examine the specimen under high power. How does the shape of the nucleus in a dividing organism compare with that of a paramecium not undergoing fission? Add the nuclear structures to your sketch. What is happening to the nuclear material?

Examine the slide under low power and look for several stages of fission. Make a series of drawings showing your understanding of the sequence of events from the onset of fission until the two organisms appear held together by a very narrow bridge of cytoplasm. What is the over-all result of this constricting process?

C.2.a and C.3.a may be done in one lab session.

Materials and Equipment

Compound microscope
Prepared slides of paramecium fission

Although it is much more exciting to watch fission in living cultures, it is more reliable to use prepared slides for this study. It is suggested that the teacher set up for demonstration living examples of fission if they can be found. The student may compare what he observes in living examples to what he discovers in his study of the fixed, stained specimens. Normally, if the culture is well fed and vigorous, reproduction will be occurring rapidly enough to allow finding some examples for demonstration.

It is more elongated.

It is being replicated and parceled out to the daughter nuclei.

Two individuals are produced.

You cannot say which is the parent since both are identical. Neither can one be called the "offspring" since both have come from the same individual. Both types of reproduction are cell division, but in paramecia the new individuals also are formed. It is asexual because there is no exchange of nuclear material, no gametes, no fertilization.

Materials and Equipment

Compound microscope
Prepared slides of conjugation in paramecia

The macronucleus is absorbed by the cytoplasm. The micronucleus divides (meiotically).

No, the condition is not similar; see above. There is nuclear exchange and reorganization.

Which organism is the "parent?" What similarity do you see between mitosis and this type of reproduction? Why is fission considered to be asexual reproduction?

C.3 - SEXUAL REPRODUCTION IN PARAMECIUM

Paramecia also reproduce sexually by means of a process called conjugation. Again we will use prepared slides to observe this process.

C.3.a - Experiment: CONJUGATION

Obtain a prepared slide from your teacher and observe under low and high power. Locate two paramecia which appear to be stuck together side by side. These organisms are undergoing conjugation. Watch the organisms for a time. Make an outline sketch of the two. Compare the appearance of the nuclei with those of the paramecia on the slide which are not undergoing conjugation. How do the nuclei differ? Is the condition of the nuclei similar to that observed in paramecia undergoing fission? From your observations can you form any hypotheses about what is occurring between the two paramecia undergoing conjugation? Following this process, the two organisms will separate and each member will immediately undergo cell division.

Although partners undergoing conjugation are structurally identical, it has been found that they belong to different mating types. This means that a paramecium of mating type I will conjugate only with an individual of mating type II and vice versa. Thus, while structurally the same, functionally the two partners are different and therefore somewhat analogous to male and female forms in higher organisms.

Do you think fission or conjugation would be the more advantageous type of reproduction for continuing the species under changing environmental conditions? Why? Under what conditions do you think the alternate process might be more advantageous?

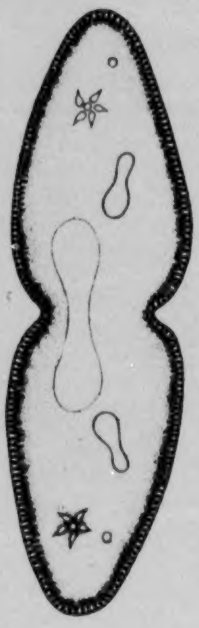


Figure C.2

Some explanation and discussion of mating types will be necessary. The concept of primitive differentiation of definite sexes should be explained, emphasizing that the strains differ physiologically only, not morphologically. It may be interesting to set up a demonstration of live organisms in which one strain has been marked with vital stain (such as Evans Blue or Janus Green) to show that members of a particular strain do not conjugate with members of the same type.

A Sourcebook for the Biological Sciences, Morholt, Brandwein, Harcourt, Brace & Co; gives information on vital staining.

Conjugation, because it allows for nuclear recombinations resulting in a more variable population, some members of which might have some advantages in a changing environment.

Whenever it would be advantageous to produce large numbers of similar organisms rapidly, such as during invasion of an unpopulated area or at a time when environmental change is very slow.

As an optional study, living cultures may be used for studying conjugation in preference to prepared slides. (Prudence suggests, however, having a few commercially prepared slides of this process on hand.) It has been found that conjugation is encouraged by starving the cultures following a period of rich feeding. Also, overcrowding will initiate the process. The cultures pur-

chased from a supply house are normally ready to conjugate when the two strains or types are placed together. To prepare for the laboratory, proceed as follows:

Using separate droppers, approximately 24 hours before the scheduled laboratory, mix some paramecia from each of the two cultures in depression slides; seal a coverslip over the well with petroleum jelly; place the slides in a covered finger bowl containing moistened paper toweling. Although conjugation will begin soon after mixing, more pairs are typically observable about a day later. For their size, paramecia are rapid swimmers and unless slowed down somewhat are difficult to study alive under the microscope. Methyl cellulose may be used to restrict their rapid movement. Make a ring of methyl cellulose solution about 1 cm. in diameter in the middle of a clean microslide. Place a drop of paramecium culture in the middle of this ring; place a coverslip in position and observe under the microscope.

A few drops of iodine stain, placed at one edge of the coverslip and drawn under by means of a small piece of paper toweling applied to the opposite edge, will kill the paramecia and stain them so that the nuclei of each cell becomes visible.

C.4 - SEXUAL REPRODUCTION IN MULTICELLULAR ORGANISMS

In multicellular organisms sexual reproduction begins with the production of a sex cell within the body of the parent organism. Within the reproductive organs (gonads) a specialized form of cell division produces a sperm or egg which contains one half of the hereditary information possessed by the body cells. These reproductive cells (gametes - Greek, to marry) are brought together in fertilization, the union of sperm and egg. The fertilized egg (zygote), which now has a full complement of hereditary information, then undergoes repeated cell division (mitosis) and gives rise to a new individual.

C.4.a - MEIOSIS

In cells other than gametes, the chromosomes are in pairs. The gametes have only one member of each chromosome pair. The special type of cell division which reduces the chromosome number in the cell one half is meiosis.

It is intended that the process of reduction division be clear to the student before he proceeds.

Study the diagram of meiosis on the next page. How was the original chromosome number reduced by 1/2 during these two divisions? If a cellular division occurs without a chromosome duplication the chromosome number will

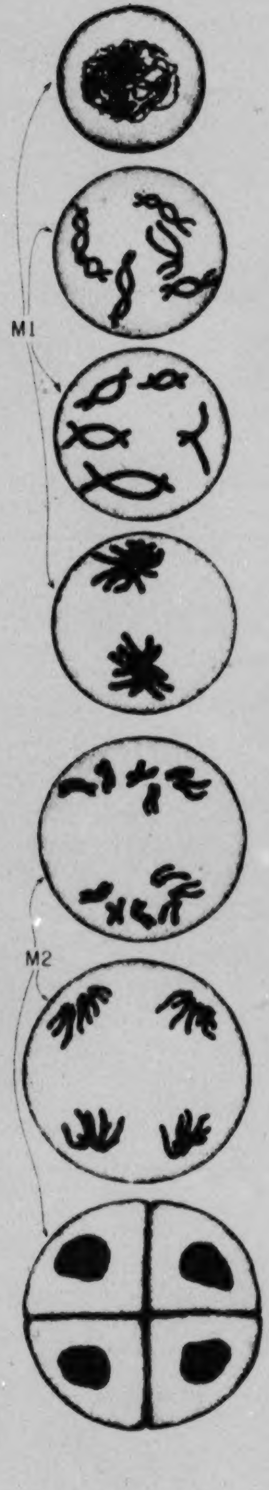


Figure C.3.

inevitably be halved, assuming that half of the chromosomes go into one of the resulting cells and the other half into the other. By exactly the same reasoning it should be clear that if there are two cellular divisions with but a single chromosomal duplication, the chromosome number of the four resulting nuclei will be halved. It is this latter situation that occurs in meiosis.

With the aid of the illustration of meiosis in the student guide and the film - "Meiosis: Sex Cell Formation" EBF - 16 minutes, the teacher will need to lead the students through the sequence of meiosis called oogenesis in which one viable egg and two polar bodies are formed.

The cells that result from the two meiotic divisions contain only one member of a given homologous pair of chromosomes. (A homologous pair has two members which have the same proportions.) Thus there has been not only a halving of chromosome numbers but also a segregation of the members of each homologous pair of chromosomes into separate nuclei.

HDL - A pair of organisms which have 6 chromosomes (3 pair) are mated. Construct one chart for the male (sperm) and one chart for the female (egg or ovum) to show how gamete formation occurs in each parent.

There would be four sperms and one egg formed, each with three chromosomes.

A quick look at the HDL's will inform the teacher "where the students are," and he may review gamete formation or go on to fertilization, using the HDL as the vehicle.

Equipment and Materials
(Teachers)

- 4-5 urchins (this should give a reasonable chance of including both sexes)
- 20 ml 0.5 M KCl
- 5 ml syringe and needle
- Aquarium and sea water
- 150 ml beaker or finger bowl
- Petri dish
- Several droppers or pipettes

Equipment and Materials
(students)

- Microslides
- Toothpicks
- Syracuse watch glasses
- Microscopes

This exercise is basic and can be one of the most dynamic and dramatic laboratory experiences of the year; teachers living near a coastal region are indeed fortunate. The actual instant of fertilization is a sight rarely seen. This experiment should be attempted during spring when the urchins are gravid.

Sea urchins (in the Pacific Northwest the common species is *Strongylocentrotus purpure*, the purple urchin), can be collected from many regions of the rocky intertidal zone during low tide the weekend before they are to be used. (Certain areas of the coast are closed to invertebrate collecting. If you are uncertain of the regulations, it would be wise to check with the State Fish Commission about closed areas or to apply for a collecting permit about three weeks before anticipated collectings.) The urchins will live very satisfactorily for a few days in aquaria if kept in a refrigerator in plenty of sea water. Do not overcrowd. Be sure to bring back

C.4.b - Experiment: FERTILIZATION

Following the production and release of eggs and sperm, the next step in sexual reproduction is fertilization, when two gametes combine to form a zygote. If all goes well, you will be able to observe this fascinating and dynamic process under the microscope.

Before the laboratory period, your instructor should have obtained freshly released eggs and sperm from live female and male sea urchins. The gametes are kept in cold sea water approximating their natural environment as closely as possible.

several gallons of sea water for each dozen or so urchins collected.

Although students can induce shedding of gametes, much time and confusion can be saved if this is done before class by the teacher. Induction can be accomplished in several ways:

(1) injection of KCl solution;
(2) subjection to electrical stimulus; or
(3) dissection of the gonads

The KCl treatment is as follows: Inject approximately 2 ml of 0.5 KCl into the body cavity through the membrane around the mouth; place upright on a clean glass plate or pan until the animal begins shedding gametes (recognizable by the oozing of either a milky sperm or yellowish eggs secreted from the dorsally located gonopore). Place the female urchin over a beaker or finger bowl containing 25 ml of fresh sea water; allow the eggs to drain in and settle, then wash three times by draining the water and replacing with fresh sea water. Invert male over a petri dish with a small amount of sea water and allow the sperm to drain into it. Keep these gamete solutions cool and use as soon as possible - the eggs within four or five hours, sperm within an hour or less.

For the electrical treatment, stimulate the dorsal surface of the urchin with an electric shock of about 6 volts until the gametes begin oozing from the gonopore and proceed as above.

Mechanically, the gametes can be obtained by breaking the shell and dissecting out *the gonads. Macerate the gonads in fresh sea water and proceed as above.*

Students should be cautioned not to mix the pipettes when obtaining the gamete suspensions.

The nucleus should be discernible from the cytoplasm. Sperms are elongated, whitish in aggregate, and much smaller. The eggs are round, yellowish, and about 60-70 microns in diameter. Specialization and division of labor are advantages. Sperm are adapted for locomotion or swimming. The egg contains much stored food material for the developing embryo. Thus we see some of the advantages of specialization and division of labor.

Typically they increase their swimming movements rapidly. The fertilization membrane forms in a very few minutes or less. It appears to aid in preventing more sperm from entering the fertilized egg.

Obtain a clean microslide and, using a clean pipette, place on it a drop of the egg suspension. Close to the side of the drop of eggs, but not touching it, place a drop of the sperm suspension, using a different pipette. (Why should you use different pipettes transferring the two suspensions?) Carefully observe a sea urchin egg. Note its size, shape, and color. Can you detect any details within the egg? Now look carefully at the drop of sperm. Watch their movements. What is their shape, color, and size? Compare the egg and sperm in regard to these structural characteristics. Can you suggest any advantage in producing gametes of two different morphological kinds? For what are sperm particularly adapted? How is the egg especially suited for its role in reproduction?

Now, while looking through the microscope use a toothpick to draw part of the sperm suspension over to the drop of eggs. Mix them together and watch. You should see a rare and fascinating sight. Make a note of the time when you first mixed the gametes.

What response do the sperms exhibit with respect to the eggs? Very soon after the penetration of an egg by a sperm a fertilization membrane lifts off from its surface and surrounds the egg like a halo. How long did it take from the first contact of sperm with an egg for this fertilization membrane to form? Can you suggest a function for the fertilization membrane?

Within an hour or so, the fertilized egg (zygote) will start to divide into two cells as the new individual begins to develop into an embryo. Shortly each of these cells will divide again to form four. These produce eight, and so on. If the zygotes are kept in fresh, cool sea water in a shallow dish, such as a Syracuse watch glass placed in a refrigerator, you should be able to observe development of these stages over a period of hours and days.

In many animals, testes and ovaries are located in the same individual. Give several examples. Can you suggest any advantages to this arrangement? Can you suggest disadvantages? How could these disadvantages be reduced?

D. -- EMBRYOLOGY - DEVELOPMENT

D.1 - Experiment: DEVELOPMENT OF SEA URCHIN EGGS

Obtain a prepared slide from your teacher and observe it under low and high power of the microscope.

Fertilization is the fusion of two sex cells to form the zygote, which has both members of each chromosome pair. After fertilization, the

Although not strictly a part of this exercise, the teacher can get a great deal of "extra mileage" out of this material by placing the zygotes in Syracuse watch glasses in the refrigerator and allowing students to watch early stages of cleavage from several hours to several days after fertilization.

Starfish may be used in place of the sea urchin. The arms (rays) of the starfish contain pairs of male or female gonads.

Film: "Echinoderms - Sea Stars and Their Relatives," EBF (17 minutes) - contains a section showing the stimulation and release of eggs and sperm from the sea urchin.

Advantages: For animals which have restricted locomotion it might eliminate the problems of finding mates; and it allows both members which mate to produce offspring. Disadvantages: Self-fertilization reduces the advantage of sexual recombination and limits the availability of many factors in the gene pool. Disadvantages could be minimized through development of devices to reduce chances of self-fertilization such as different maturation times for the gonads or morphological arrangements which preclude or inhibit self-fertilization.

Materials and Equipment

Microscope

Prepared slides of Arcabia (sea urchin) unfertilized, all cleavage stages, blastula and gastrula.

Two good references:
An Atlas of Embryology, Freeman and Bracegirdle, Hermann Ed. Books Ltd. London.

Experimental Embryology, Rugh, Robe Burgess Publishing Co., Minneapolis.

Embryology is a fascinating topic and it lends itself well to the kinds of skills which first year students have. The problem is time. If you feel that time is not a problem in your case or that this is a critical topic, pursue it. The third year plan calls for development as a monograph topic. You may elect to allow some individuals in the class to pursue this topic more or less on their own time.

***Minimal coverage is the set of topics which involve** no live animals other than the mice and tadpoles (perhaps up until hatching). There are at least films:*

"Fish Embryo from Fertilization to Hatching" EBF 12 min.

"Chick Embryo" EBF 13 min.

The students should look for stages and structures they have seen in sea urchin development and be prepared to make comparisons later when OBSERVING TADPOLES. They should note developments beyond those they have seen.

Use of a film may lessen the work and time invested and still permit the kinds of observations which are needed.

Another recommended film is: "Eggs to Chickens," Bailey 1953, 10 min.

sea urchin egg cycles through six mitotic divisions resulting in a mass of 64 cells.

Draw the unfertilized egg, then locate those stages of cleavage in which groups of two, four, eight, sixteen, thirty-two, and sixty-four cells are observed. Make some drawings of those stages you observed.

A cell from any of these groups, if separated, is capable of developing into a complete sea urchin.

When the cell mass reaches this stage, many of the cells are no longer in contact with the water; they are buried within the cell mass. At this time the ball of cells takes on a new look; you will observe many hollow-looking balls as all the cells take positions which bring them into contact with the water. Draw one of the hollow ball stage cell masses.

The next phase involves very rapid cell division in one area of the ball. Cells of this region grow so much faster than the rest of the cells that they override the area of slow reproduction. This results in two noticeable changes: (1) the hollow mass of cells looks as if one side had caved in, and (2) the cells in the concave region are much larger than the fast-reproducing cells which are now on the outside of the mass. The mass, which is still hollow, now consists of two layers, one within the other, with all cells in contact with the surrounding fluid. The two layers of cells are called the endoderm and ectoderm. Draw an example of this pushed-in hollow ball stage.

In most animals, a third layer of tissue, the mesoderm, develops. These inner, middle, and outer layers each develop into particular parts of the body. For instance, the skin, hair, brain and other parts develop from the outer layer, most bones and muscles come from the middle layer, and the inner layer gives rise to the digestive system.

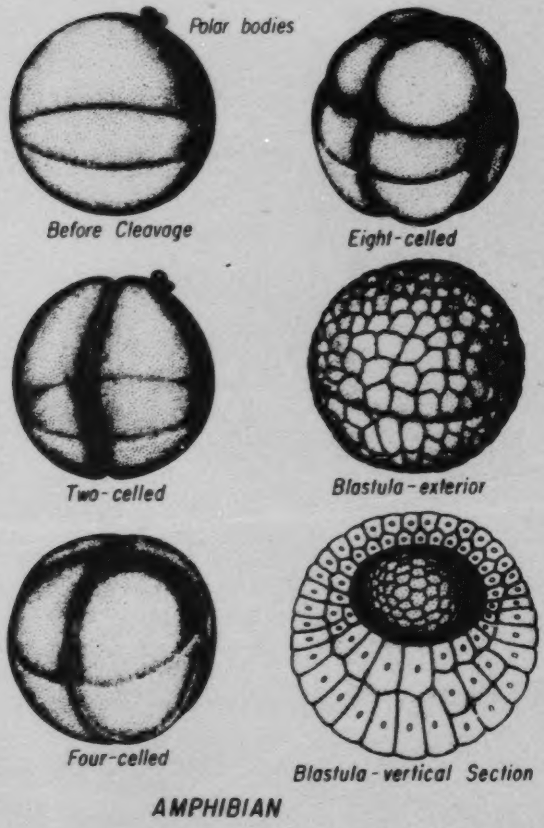

Polar bodies
Before Cleavage
Eight-celled
Two-celled
Blastula-exterior
Four-celled
Blastula-vertical Section
AMPHIBIAN

Figure D.1

Observing the changes of many developing organisms is interesting, but you will have to decide if there is time to explore this concept at length.

Fertilized chicken eggs and/or newly laid and fertilized frog eggs can be observed over a period of days to see the gross external changes which result from more subtle cell, tissue and organ changes in the embryo or larva (free living embryo).

On p 36 you will find instructions and schedule to assist in incubating chicken eggs.

In late February and March, frog eggs may be found in ponds and streams. A word to the student will usually result in class quantities that may be used for extensive study of occasional observation.

The frog egg development responds well to temperature gradient and microscopic examination revealing embryonic development.

Boiled lettuce or spinach, fresh or in prepared baby food, may be used as food for the developing tadpoles. They eat very small amounts. Surplus food becomes toxic. Shumway's chart is based on 18°C. You can control speed of development by regulation of temperature.

D.2 - DEVELOPMENT OF THE EMBRYO

As the presumptive tissues (layers) develop and take on more specialized activities the cells themselves become more varied in function and in appearance. The variety of kinds of cells in a mature multicellular organism such as yourself is surprising considering that they are the direct descendents of a single zygote (fertilized egg). Some of them are extremely long (nerves from toes to spinal cord), but cannot contract, others are long and are able to contract (muscle), some produce chemicals (digestive glands, for instance), others are sensitive to certain stimuli, and so the list goes on.

D.3 - DEVELOPMENT OF A FROG

In February and March you can find clusters of frog eggs in ponds and streams. You may wish to continue your observations of embryonic development at school or home. A hand lens and baby food jars of water with four or five eggs in each may provide many hours of exciting observation. The development of the frog embryo is affected by temperature variation. You might use an incubator, refrigerator, an open room, and

Development in the Snail:

Another possible lab experiment for studying embryology makes use of the bubble snail. The following lab procedure was developed by Dan Fields, a student at Wilson High School (Portland, Oregon), under the supervision of Jean Chisholm.

Bubble snails (Physa heterostrophia) and their eggs may be collected from outdoor ponds. An easy way to culture them in the lab is to place 10 to 20 snails in a gallon jar filled to 3/4 its capacity with pond water. The water in the jars should have a pH of 5-6; the jars should be kept in a light source, such as a neon Gro-Light. Elodea or duckweed should be added to the water as an oxygen source and also to provide egg-laying surfaces.

Snails will lay eggs prolifically (adequate for 9 or 10 classes) under good conditions. Egg-laying is enhanced by feeding with 0.03 gm of "low calorie diet aid" added to the water every 3 days. Embryos are stored in fresh pond water or distilled water in petri dishes. Egg clusters can be transferred using forceps to lift them. Fresh water should be added daily to insure an adequate oxygen supply for the embryos.

An easy way to store embryos for observation is to place them in depression slides with vaseline-sealed coverslips over them to prevent drying. If the slides are stored at night in petri dishes of pond water within a refrigerator they should be available for observation for several days.

Using a microscope, students should be able to make good observations and drawings. At Wilson High drawings were left by the microscope throughout the day, with successive classes added to the pictorial record.

Materials and Equipment:

Microscope
Gro-Lamp
Aquarium or gallon jars
Pond water
Distilled water
Petri dishes
Slides, coverslips
Vaseline
pH paper
Forceps
Elodea and duckweed
Bubble snails (*Physa heterostrophia*)

Development in the Chicken:

With a little bit of luck the following method for preparing different stage embryos will permit observations to be made in one or two days rather than many observations over the three-week incubating period. 0, 2, 5, 7, 9, and 21 are a convenient and appropriate number of days for incubation and can be marked on the sets of eggs.

	M	Tu	W	Th	F	S	Sun
Week one			21				
Week two							
Week three	9		7		5		
Week four	2		cracking-hatching day(s)				

Clues on how to incubate with success:

1. Humidify with a dish of water in the incubator; the larger the surface and the cleaner the surface the better.

2. Keep temperature at 101-103^{o}F.

3. Turn eggs three times a day.

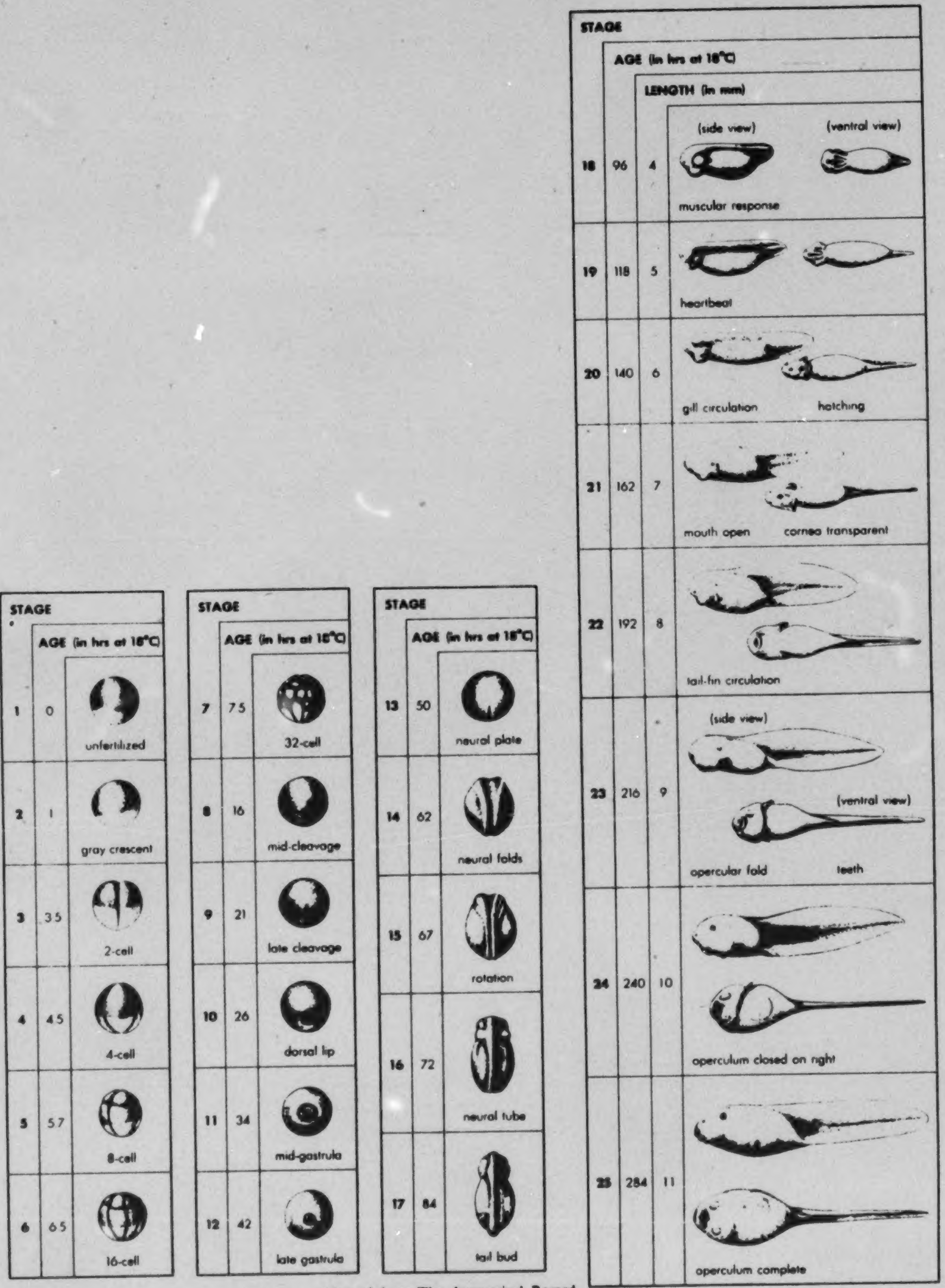
Clues on storage of eggs until incubation (longer than 10 days leads to less success):

1. Keep cool at about 50^{o}C.

2. Store with large end up.

Clues (misc.):

After the shell is broken, the embryo will live longer if bathed in a physiological saline solution (.9%), 90 grams NaCl/Liter H_2O, or bird Ringers solution.



STAGE	AGE (in hrs at 18°C)	
1	0	unfertilized
2	1	gray crescent
3	3.5	2-cell
4	4.5	4-cell
5	5.7	8-cell
6	6.5	16-cell

STAGE	AGE (in hrs at 18°C)	
7	7.5	32-cell
8	16	mid-cleavage
9	21	late cleavage
10	26	dorsal lip
11	34	mid-gastrula
12	42	late gastrula

STAGE	AGE (in hrs at 18°C)	
13	50	neural plate
14	62	neural folds
15	67	rotation
16	72	neural tube
17	84	tail bud

STAGE	AGE (in hrs at 18°C)	LENGTH (in mm)	
18	96	4	(side view) (ventral view) muscular response
19	118	5	heartbeat
20	140	6	gill circulation hatching
21	162	7	mouth open cornea transparent
22	192	8	tail-fin circulation
23	216	9	(side view) (ventral view) opercular fold teeth
24	240	10	operculum closed on right
25	284	11	operculum complete

Adapted from The Anatomical Record

Schumway's chart showing stages of development of the frog.

a window sill as your gradient series or you may select your own gradient. A Shumway chart of frog development will give you a basis for comparing temperature or time as they affect the development of the embryo. (see previous page)

E. - BIRTH

Development may be either external, as in the organisms you have seen, or internal, as in the placental mammals. In the latter, such as our mice, these processes are more difficult to observe and therefore to explain. Furthermore, it is only in animals which have internal development that birth occurs. We may rely on a film presentation for information on internal development and birth of such an embryo.

Films:

"Biography of the Unborn" EBF (17 minutes) - discusses fertilization and birth.

"From Generation to Generation" McGraw-Hill (32 minutes) discusses basic human reproduction; shows childbirth as an emotional and spiritual experience as well as physical; animation explains creation and development of new life.

"How Life Begins" 3M

"Human Reproduction" EBF

F. - MATURATION

A traumatic orientation to a new environment begins with the birth of the offspring. The maturation of a mouse is a process that you have observed in the mouse colony. On the basis of the data recorded from those observations you are asked to answer the following questions. Try to base your answers entirely on your observations.

1. What was the period of gestation (pregnancy) of the mouse?

1. The period of gestation is from nineteen to twenty-one days. Variations are due to strain difference and size of litter.

2. The size of litters varies greatly but may be as many as fourteen. Hybrids tend to have larger litters than inbred strains. The number of survivals would be based on observation.

3. The lactation period is dependent on the size of the litter and is from 21 to 28 days.

4. a) The day the mice are born they are naked and lack pigmentation other than in the iris of the eye; the eyes and ears are closed, and the ears are lying flat against the sides of the head.
b) The pigments begin to show in the skin if the strain is colored.
c) The external ears are open and are not as flat on the head.

5. The abdominal wall is still transparent enough to see through on the fourth day and milk can easily be seen in the stomach.

6. On the fifth or sixth day the body becomes covered with little hairs, and by the seventh day the entire body is covered.

7. By the tenth day the nipples can be seen and the sex of the mouse is evident. Anus to vent distance is most reliable.

8. On the twelfth day the incisor teeth erupt.

9. By the fourteenth day the eyes are open, the ears start to grow, and the mice begin to eat solid food.

2. How many mice were in the litter observed?

3. Lactation is the period during which the female nurses her young. What was the lactation period for your colony?

4. What was the appearance of the mice
    a) when they were born?
    b) on the second day?
    c) on the third day?

5. Did you ever observe milk in the stomach?

6. When did the body covering (hair) appear?

7. At what age could you determine the sex of the mice?

8. When were teeth observed?

9. At what age did the eyes open?

10. At what age do the mice mature sexually?

10. As early as five and one-half weeks and as late as eight to ten weeks.

Chapter II: GENETICS

The first person to discover the basic laws of heredity was Gregor Mendel, who investigated the pattern of inheritance in peas over one hundred years ago. The results of his experiments and the conclusions he drew from them are still valid today. Before Mendel's results became known, it was commonly believed that the traits of an individual were a blend of the traits of his father and mother. This idea is common even today and is expressed in such terms as "mixed-blood." Mendel's great discovery was that the idea of blending is inaccurate and that even though blending may seem to occur the contributions of the mother and father remain separate and distinct. In addition, Mendel showed that most characteristics are inherited independently of each other, so that offspring have random assortments of their parents' characteristics. It is as if one's characteristics were obtained by shuffling a deck of cards and dealing a hand, rather than by blending. In the following experiments you will retrace the steps which led to Mendel's conclusions.

References:

General Genetics,
Srb and Owen ; Freeman

Human Genetics,
Curt Stern ; Freeman

The New You and Heredity,
A. Scheinfield

A. - MOUSE GENETICS

You will be asked to make observations on coat color and ear size for three generations of mice from the mouse colony. These observations constitute the data of a breeding experiment. The first generation is called the parental generation (abbreviated P). The ancestors of one parent were consistently black and small-eared while those of the other were consistently white and large-eared. The second generation consists of the offspring of the P mice and is called the first filial generation (abbreviation F_1). The third generation consists of the offspring of the F_1 mice and is called second filial or F_2 generation.

A.1 - Experiment: MOUSE GENETICS

Examine the F_1 mice. What has happened to the traits, white coat and small ears? Have they entirely disappeared from F_1 or are they present in masked form? Does it make any difference if the solid black, small-eared parent is male or female? Examine the F_2 mice. How do you explain the reappearance of white coat and small ears? Do you observe any grey mice or mice with intermediate sized ears? Determine the percentages of white and solid black mice in the F_2. Can you devise a scheme to explain both the disappearance of white mice in the F_1 and the

It is recommended that the analysis of the genetic data from the mouse colony take place as a class discussion which leads to the development of the Mendelian model in the following sequence:

1. The disappearance of a P trait in the F_1 and its reappearance in the F_2 is most simply explained by assuming the existence of "factors" or "elements" or "units" which can be masked but which remain unmodified. This leads to the concept of dominant factors and recessive factors. The factors are usually called genes.

2. The fact that it makes no difference which parent is black indicates that each parent contributes equally to coat color. The simplest assumption is that each individual receives one gene affecting coat color from each parent.

percentage of white mice in the F_2? Does the same sort of scheme apply to ear size? Is there any tendency for coat color to be associated with ear size? Notice that new combinations of traits appear in the F_1 and F_2 generations. For example, you should be able to find a white, small-eared mouse in the F_2, as well as many solid black, large-eared mice.

3. Introduce genetic notation. Use capital letters for dominant traits and lower case letters for recessive, e.g. B and b for black coat and white coat or E and e for large ears and small ears. Introduce the term allele. An allele is any one of several alternative states of a given gene. Thus B and b are alleles.

4. Develop model for coat color assuming segregation of alleles in gametes:

P BB x bb

gametes B and b

F_1 Bb x Bb

gametes ½B½b and ½B½b

F_2 ¼BB ½Bb ¼bb

5. Apply model to ear size.

6. Show coat color and ear size are entirely independent of each other.

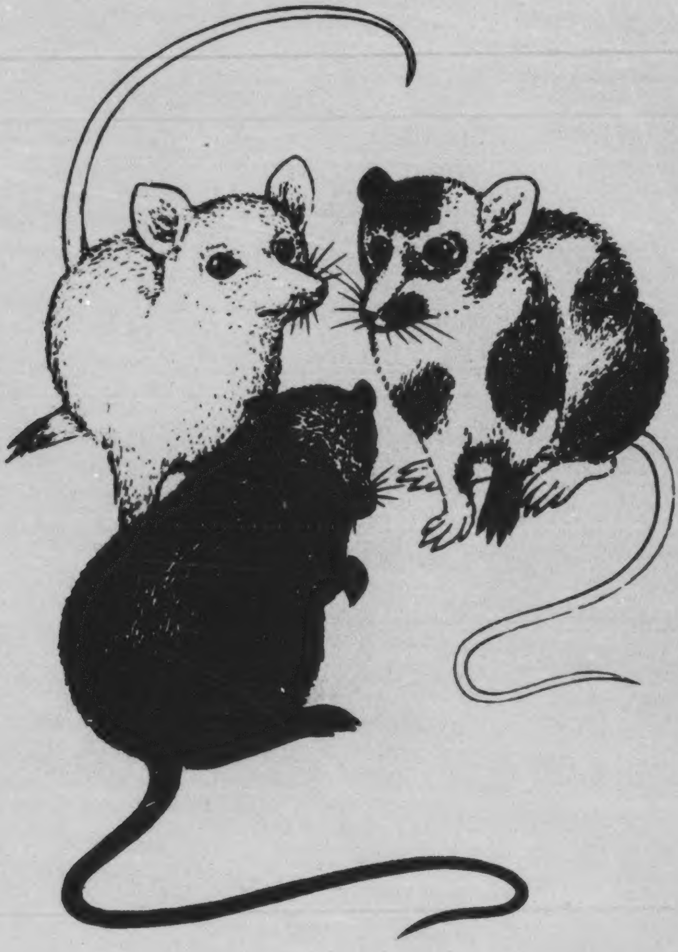
7. Generalized model.

8. The number of F_2 mice will probably be too small to give a good fit to the predicted ratios.

BB x bb

	b	*b*
B	*Bb*	*Bb*
B	*Bb*	*Bb*

	B	*b*
B	*BB*	*Bb*
b	*Bb*	*bb*



B. - PROBABILITY AND GENETICS

In most multicellular organisms the development of an individual requires the union of male and female gametes, and both the production and the coming together of the various possible types of gametes takes place at random. Randomness is a chance phenomenon allowing for variety among species. For example, man has 23 pairs of chromosomes in each body cell. There are 23 single chromosomes in each sperm and egg. At fertilization the 23 chromosomes of the sperm pair with the 23 chromosomes of the egg restoring the original number of 46 (23 pairs). However, since there is no pattern for the shuffling of the chromosomes during sperm and egg formation there are 2^{23} (4,168,064) possible types of eggs and sperms that can be formed by each female and male respectively. Small wonder that no two brothers or two sisters look alike (excluding identical twins)!

B.1 - Experiment: PROBABILITY

Obtain two pennies. Using a felt pen, mark the head side of one J and the tail side j. Similarly mark the head of the other D and the tail d. Assume J = loose ligaments, j tight ligaments, D = dimples, and d = no dimples as in humans. In the tossing of a coin the chances

Materials and Equipment
2 pennies (or other like coins) for each pair of students
marking pen

The traits suggested here are described more completely in sec. D.2, Human Genetics. Students will engage themselves in this problem more enthusiastically when working with human traits than with those of mice, corn, or fruit flies.

that it will fall heads or tails are even, fifty-fifty. Choose a partner and perform a "breeding experiment" as follows: Flip each of your coins. The result gives the genes for double jointedness and dimples in a gamete of parent #1. In the same way, your partner will get the genetic constitution of a gamete of parent #2. Combine the gametes to form an individual and record the results in Table B.1. Example:

	Gametes of:				Resulting Individual	
	Parent #1		Parent #2			
	Coin #1	Coin #2	Coin #1	Coin #2	Genotype	Phenotype
toss 1	J	d	J	D	JJdD	double jointed, dimples
toss 2	j	d	j	d	jjdd	not double jointed, not dimples
toss 3	j	D	J	d	jJDd	double jointed, dimples

Table B. 1

Genotype is the genetic composition of an organism. The alleles make up the genotype. Phenotype is the visible expression of the genes. Individual 3 has double-jointed thumbs and has dimples, due to genes J and D, which are dominant over j and d.

Each pair should make at least 20 tosses. How closely do your results agree with expectation? Now pool your results with those of the other pairs and again compare the results with expectation.

Gametes of:					Resulting Individual	
Parent #1			Parent #2			
	Coin #1	Coin #2	Coin #1	Coin #2	Genotype	Phenotype
toss 1						
toss 2						
toss 3						
toss 4						
toss 5						
toss 6						
toss 7						
toss 8						
toss 9						
toss 10						
toss 11						
toss 12						
toss 13						
toss 14						
toss 15						
toss 16						
toss 17						
toss 18						
toss 19						
toss 20						

Table B.2

You have now arrived at the theory of heredity as it was originally developed by Mendel. He argued as follows: Each characteristic of an individual is controlled by a pair of factors (genes); one gene of the pair comes from the father and one from the mother. When the individual forms gametes, only one gene of each pair goes into any one gamete (meiosis). Which member of a pair goes in is entirely a matter of chance, so half the gametes will have one member and half will have the other member of the pair. In addition, some genes are dominant and some are recessive. By these hypotheses Mendel was able to explain his results in crossing peas, just as you have done with mice. Of course not all traits are inherited in such a simple fashion. Often several pairs of genes are involved in producing one trait. For example, this seems to be true of skin color in humans, where it has been suggested that five pairs of genes cooperate to produce the many different colors of skin found among humans.

Mendel did not know anything about the nature of genes nor why only one member of each pair goes into a gamete. We now know that genes are found in the chromosomes of cells and that very precise mechanisms exist to ensure that the chromosomes are properly distributed to daughter cells during cell division. Moreover, chromosomes exist in pairs, and when gametes are formed only one member of each chromosome pair enters a gamete. The behavior of chromosomes and the fact that genes are in the chromosomes explains Mendel's results.

We also know that genes are specific portions of exceedingly long molecules of a substance called DNA, and that the DNA is found in the chromosomes. Each body cell of a human being, for example, has 46 chromosomes, and each chromosome has enough DNA for several thousand genes. As far as we know, all of the hereditary traits of a person are controlled by these genes.

C. - HUMAN GENETICS

As was suggested before, the principles discovered by Mendel apply also to human beings. Of course, it is not possible to carry out breeding experiments with humans, but by collecting observations on family trees and on populations it is possible to learn something about human inheritance.

Examination of pedigrees of individuals who are in some way different from the average often shows that the difference is inherited in a Mendelian fashion. For example, certain individuals are albino--that is, they are unable to manufacture the pigment melanin, which is normally found in the skin, hair, and eyes. Albinos have white hair and extremely pale skin, and their eyes are red or pink. Exposure to the sun is extremely dangerous for an albino because he has no pigment to protect him from the ultraviolet rays of sunlight. Albinos can be the offspring of normal appearing parents, and they can have normal appearing brothers and sisters. Moreover, about one out of four children in such families are albino and the rest are normal. These observations can be explained by assuming that there is a dominant allele, A, which causes the production of melanin, and a recessive allele, a, which cannot bring about the production of melanin. An albino, therefore, must be homozygous, aa. Normal people must be either homozygous, AA, or heterozygous, Aa. If an albino has normal parents, then each parent must be heterozygous, Aa. What proportion of an albino's brothers and sisters would you expect to be heterozygous?

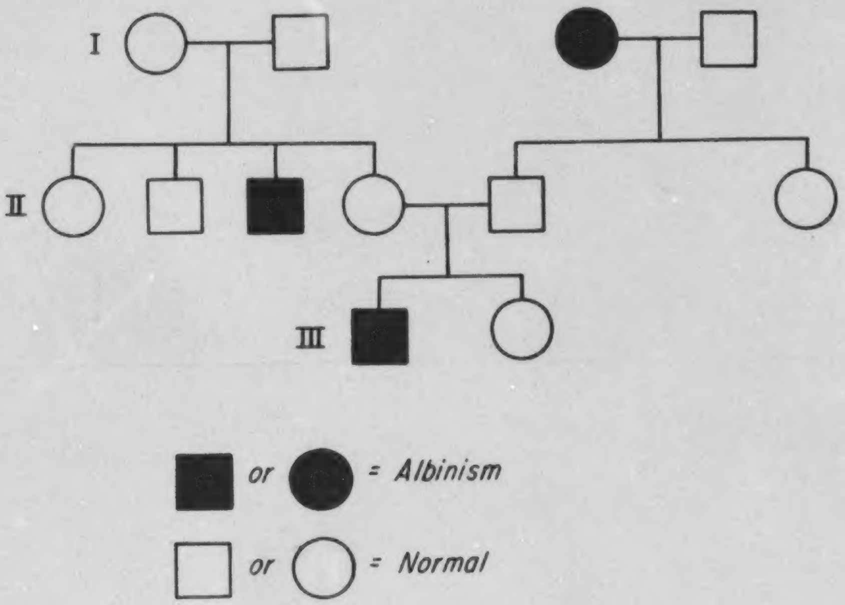
Homozygous means two alleles are alike; both are dominant or both are recessive.
Heterozygous refers to a pair of unlike alleles, where one is dominant and one is recessive or where two unlike dominant genes are paired, as in blood type AB.

C.1 - PEDIGREE OF ALBINISM

In a diagram of pedigree the squares are used to designate males and the circles females.

Horizontal lines connecting a square and a circle indicate a marriage. The vertical line leading downward from a horizontal line leads to another horizontal line from which other vertical lines lead to individual offspring. The Roman numerals indicate generation.

A PEDIGREE OF ALBINISM



[illegible].2 - Experiment: HUMAN BLOOD TYPES

Another set of alleles in humans which has been extensively studied is the genes controlling human blood types. These genes

Materials and Equipment
- *sterile disposable lancets, one per student*
- *clean glass slides, two/student*
- *alcohol*
- *cotton*

glass-marking pencils
anti-A serum
anti-B serum
toothpicks

determine the chemical nature of the surface of the red blood cells. One such group of alleles is the ABO group. The A and B alleles are dominant while O is recessive. Each person has two of the three possible alleles, one from each parent. Therefore, six combinations may occur, resulting in the four known ABO types. They are as follows:

AA AO	Type A blood
BB BO	Type B blood
AB	Type AB blood
OO	Type O blood

People with type A blood have the A substance on the surface of their red cells and anti-B substance in their blood plasma. People with type B blood have B substance on their red cells and anti-A in their plasma. Similarly, type AB blood has both A substance and B substance on the red cells and no anti-substance in the plasma, while type O blood has no substances on the red cells and both anti-A and anti-B in the plasma. Blood cells with A substance on their surfaces (A or AB) will clump together if they are placed in the presence of anti-A; those with B substance (B or AB) will clump in the presence of anti-B; while type O blood cells will not clump in the presence of either anti-A or anti-B. In transfusions, in order to avoid the formation of clumps in the blood vessels of the recipient, it is necessary to "match" the blood of the donor and the recipient.

You will be asked to determine your own blood type according to the following procedure.

1. Clean your little finger with alcohol.
2. Puncture your finger with a sterile lancet and collect a drop of blood on each of two slides. Press sterile cotton on the finger to stop bleeding.
3. Mark the slides "A" and "B" respectively. Immediately mix a drop of anti-A serum with the blood on slide A and a drop of anti-B serum with the blood on slide B. Use separate toothpicks to mix the drops.
4. After mixing, look for signs of clumping of the blood.
5. The pattern of clumping will depend on the type of blood you have. Obtain your blood type from the following table:

Clumping with:		
Anti-A	Anti-B	Type
yes	no	A
no	yes	B
yes	yes	AB
no	no	0

What are the frequencies of the four blood types in your class?

We cannot directly determine the genotype of an A or a B blood type person because we have no known means to determine the second allele which is carried. It may be an identical allele or the recessive 0 allele. On the other hand, we are sure of the genotype of those people with either 0 or AB blood. However, we can often determine the second allele of an A or B blood-type person by examining the blood type of his parents and/or children.

D. - GENETIC DISEASES

No one knows for sure how many genes a human cell has in its chromosomes. There is enough DNA in the chromosomes of a cell for about 10,000,000 genes of average size, but there are reasons to believe the actual number of different genes is closer to 1,000,000 in humans, or perhaps fewer. The only genes which can be identified by genetic crosses are those which can exist in alternative forms or alleles. There are experiments which indicate that only a minority of genes can occur in alternate forms. Therefore, it should be kept in mind that geneticists can study only a small fraction of the total number of human genes.

The most common class of identifiable human genes is the type where one allele is normal and carries out its function and the other allele is defective and does not carry out any function. An example of this is albinism, where a person who is homozygous for the defective allele, a, cannot produce the pigment melanin, while a person who has even one normal allele, A, can produce melanin. If the function of a normal allele is essential to health or development, then defective alleles, if homozygous, will cause disease or prevent normal development. Thus, many genes are detected only because they are associated with abnormalities. Several hundred "abnormal" genes are known at the present time.

One well-studied example of a genetic disease is phenylketonuria or PKU. This disease occurs in individuals who are homozygous for a defective gene, p. The disease is characterized by (1) a high level of phenylpyruvic acid in the body, and (2) extreme mental retardation. The mental retardation seems to be caused by the presence of phenylpyruvic acid in the brain during the early years of life. Children with the normal allele, P, do not have a high level of phenylpyruvic acid because P produces an enzyme whose effect is to reduce the level of phenylpyruvic acid. Children who are pp cannot produce this enzyme. However, it is now possible to prevent the mental retardation in pp babies by putting them on a special diet which keeps the phenylpyruvic acid level down. By the time a child reaches age 6 either the missing enzyme or an alternate enzyme route reduces the need for a restrictive diet. This appears to be a matter of maturation. The problem now is to detect pp babies before any damage has been done.

Two films available from the State Dept. of Pub. Health are:

"PKU Detection in Oregon"
"PKU - Preventable Mental Retardation"

D.1 - Experiment: GENE FREQUENCIES IN THE MOUSE POPULATION

E = large ear (normal)
e = small ear
B = solid color (normal)
b = spotted

Determine the frequencies of the genes B, b, E, and e in the first and last generations of your mouse colony. Have the frequencies remained constant? If they have not, what is the most probable reason?

Large fluctuations in frequency occur because of small population size.

D.2 - Experiment: HUMAN GENETICS

Study the following characteristics and determine both your own phenotype and your genotype, as far as possible. Of course, if you show the dominant trait, it is impossible for you to determine whether you are homozygous or heterozygous, unless it is known that one of your parents is homozygous for the recessive trait. Where doubt exists express your genotype as, for example, A ______; if you show the recessive trait yourself, the genotype could be expressed as aa. Record your observations in chart D.1. After recording all of your observations key yourself, using the table key on page 64 . You should finally arrive at a number corresponding to your phenotype.

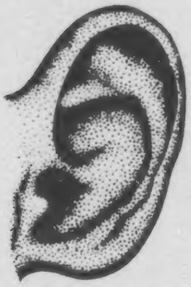
Class averages of the data might elicit discussion on human traits, including sex-linked traits such as hemophilia and red-green color blindness.

1. Eye Color. The inheritance of eye color is actually quite complex and the examples given here have been oversimplified. In blue eyes, there is no pigment in the front part of the iris, so a person with blue eyes is homozygous recessive for non-pigmented irises (bb). The presence of pigment is controlled by the dominant allele B. The amount and distribution of pigment may be controlled by a series of alleles associated with this locus or, at least in some cases, by other genes, thus

resulting in various concentrations of pigment producing eye colors ranging from hazel, green, and gray to brown and dark brown. For simplicity, we shall recognize BB and Bb as brown eyes and bb as blue eyes.

2. Taste Test. Secure a piece of paper which has been soaked in phenylthiocarbamide (PTC). Place it in your mouth and chew it. Do not swallow. Nontasters taste nothing, but tasters report a bitter taste. The ability to taste PTC is dominant, so both the homozygous dominant (TT) and the heterozygous (Tt) are tasters and the homozygous recessive (tt) is a nontaster.

3. Ear Lobes. The lobes of the ear either are attached throughout their length to the side of the head (adherent) or they hang free (pendulous). The pendulous condition (PP or Pp) is dominant; adhering lobes (pp) are recessive.



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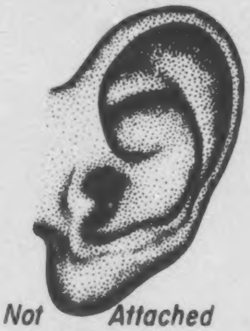

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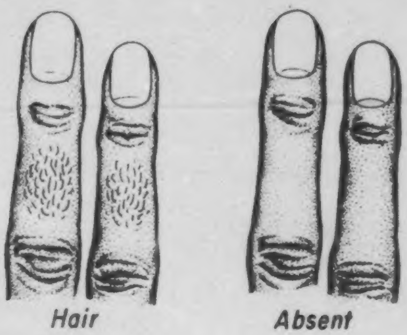
4. Mid-digital Hair. The absence of hairs on the middle segments of the fingers is

a recessive trait (mm). The presence of hair on one or more of these segments is controlled by a series of alleles, all of which are dominant over those controlling the absence of hair. For our purposes we will lump all of these alleles into a single dominant (M) which will indicate the presence of hair (MM or Mm).



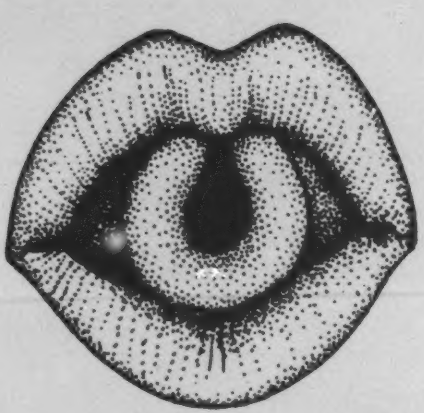
5. Bent Little Finger. The terminal joint of the little finger may be straight (ff) or bent toward the ring finger (FF, Ff).

6. Double-jointed Thumbs. The condition of loose ligaments, which permits the thumbs to be thrown out of joint, is also genetically controlled. Loose ligaments (JJ,Jj) are dominant over tight ligaments (jj).

7. Dimples. The presence of a dimple (or dimples) (D) in the cheek(s) is dominant over the lack of dimples (d).

8. Freckles. The presence of freckles (S) is dominant over the absence of freckles (s).

9. Tongue Rolling. The ability to roll the tongue into nearly the shape of a tube (T) is dominant over the lack of this ability (t).



10. Widow's Peak. The presence of a widow's peak where the hair descends on the center of the forehead (H) is dominant over the lack of this configuration (h).

11. Right-handedness is dominant over left-handedness.

12. Sex in Mammals (including man). The sex of the individual is determined by a special pair of chromosomes. Females have two "X" chromosomes of equal length, whereas males possess one long "X" and one short "Y" chromosome. Therefore, it is the male sex cell that determines the sex of the offspring.

Student's Record of Certain Hereditary Traits

Trait	Phenotype	Genotype	Trait	Phenotype	Genotype
Eye color			Sex		
PTC tasting			Double-jointed thumb		
Ear lobes			Dimples		
Mid-digital hair			Tongue rolling		
Bent little finger			Widow's peak		
Blood group			Handedness		
			Freckles		

Chart D.1.

PHENOTYPE

Eye Color	PTC	Ear Lobes	Mid-digital Hair	Bent Little Finger	Phenotype Number	Class Distribution
B	T	P__	M__	F	1	
				ff	2	
			mm	F	3	
				ff	4	
		PP	M__	F	5	
				ff	6	
			mm	F	7	
				ff	8	
	tt	P__	M__	F	9	
				ff	10	
			mm	F	11	
				ff	12	
		PP	M__	F	13	
				ff	14	
			mm	F	15	
				ff	16	
bb	T	P__	M__	F	17	
				ff	18	
			mm	F	19	
				ff	20	
		PP	M__	F	21	
				ff	22	
			mm	F	23	
				ff	24	
	tt	P__	M__	F	25	
				ff	26	
			mm	F	27	
				ff	28	
		PP	M__	F	29	
				ff	30	
			mm	F	31	
				ff	32	

Table D.1

E. - GENETICS OF POPULATIONS

So far we have been considering the pattern of inheritance within families. Now that we know something about the underlying mechanics of heredity we are in a position to apply our knowledge to the next higher level of complexity, namely inheritance in a population of interbreeding individuals. Any natural population consists of individuals who are more or less different from each other genetically. Thus a given trait, such as coat color, may be variable in a population; some individuals may have a solid color coat and some may be spotted. This means that within the population there are at least two different alleles for coat color. Some individuals will be homozygous for solid coat, some will be homozygous for spots, and some will be hybrid. The same may be true of other traits in the population. The sum total of all the alleles present in a population is called the gene pool of the population.

hybrid = heterozygous

The main problems of population genetics are to find out which alleles are in the gene pool, what their frequencies are, and how their frequencies change under various conditions. From earlier studies you know that the mice in your colony that are solid color carry a dominant allele B ___, whereas those who are not solid color are homozygous recessive bb.

Suppose that after counting the offspring in the F_1 generation of mice you found 10 solid color and 3 spotted. By simple calculation you could determine that of the 13 mice in the F_1 77% are solid color and 23% spotted. You do not, however, know whether the solid color mice are homozygous (BB) or heterozygous (Bb).

Since you do not know what proportion of alleles are B, call that proportion p. The symbol p is just a way of expressing any proportion or any per cent. It might stand for 0.15, or 0.77, or 0.90. You do not know the per cent of b alleles, either, so call that per cent or proportion q.

One thing should become apparent: if you add together all the B and b alleles, you get 100% or 1. That is, the frequency (per cent) of B alleles (p) plus the frequency (per cent) of b alleles (q) equals 100% or 1. Consider the examples below:

if p is	then q is	and p + q =
.15	.85	1.00
.77	.23	1.00
.90	.10	1.00

In each case, when p and q are added together, the total is 1. If you know the frequency of either p or q, you automatically know the frequency of the other.

To find the frequency of one allele, let us return to the concept of the gene pool mentioned in a preceding paragraph. As there is no reason why alleles should be distributed differently among males and females of the population, assume that their frequencies are the same in both sexes. Of all the sperm cells in the gene pool of the population, p of them will carry the B allele and q of them will carry the b allele. Likewise, of all the egg cells in the gene pool of the population, p of them will carry the B allele and q of them will carry the b allele (see chart below):

The existence of sex linked characteristics such as hemophilia may at first seem to negate the idea of even distribution of alleles. However, if the terms phenotype and genotype are kept clearly in mind the doubt which may surround the idea of even distribution disappears.

	Frequency of B	Frequency of b
Sperms	p	q
Eggs	p	q

Now think of these p and q values as probabilities. If a gamete were drawn at random from the gene pool, the probability of getting a B allele is p. Thus if 0.10 of the alleles are B, the probability of drawing a B allele is 0.10.

Using this information it is possible to determine what proportion of a given generation of mice will be BB, Bb, or bb. Recognize that the particular kind of sperm that fertilizes a particular egg depends only on this: the frequency of that kind of sperm and the frequency of that kind of egg in the population.

In order to determine what proportion of the next generation will be BB multiply p x p $= p^2$. Likewise, to determine the proportion of bb's multiply $q \times q = q^2$. In determining what proportion of the next generation will be Bb the student should recognize that Bb can result from two kinds of events: B sperm fertilizing b eggs (Bb), and b sperm fertilizing B eggs (bB). Each of those events has a probability of p x q, or pq. Since there are two ways that the event can occur, the probability is doubled (=2pq).

From the above it becomes apparent that a generation of mice will consist of p^2 offspring with the genotype BB, 2pq offspring with the genotype Bb, and q^2 offspring with the genotype bb. All possible genotypes are symbolized by BB, Bb, or bb, and these genotypes are represented by p^2 (BB), 2pq (Bb + bB) and q^2 (bb). Adding $p^2 + 2pq + q^2$ yields 1, where "1" represents all of the individuals in a generation.

The discussion so far is an application of mathematics to a biological problem, population genetics, and is referred to as the Hardy-

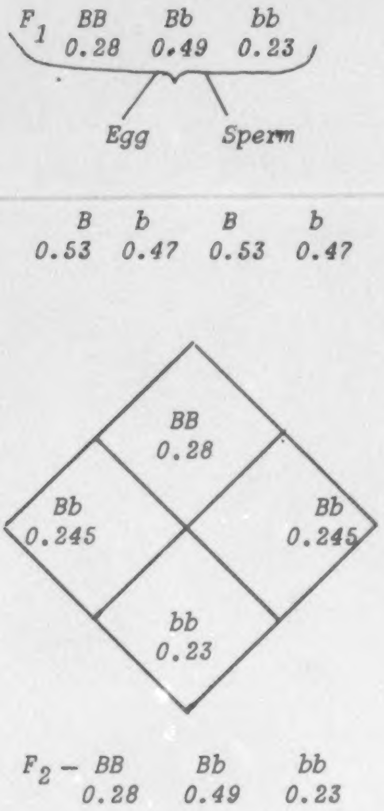
Weinberg Law. The Hardy-Weinberg Law simply states that the frequencies of the different kinds of zygotes remain the same generation after generation, if the following conditions remain constant: (1) no mutations, (2) no changes in gene frequencies, (3) no introduction of new genes into the gene pool, and (4) random mating.

Another way of stating that frequencies of the different genotypes remain the same from generation to generation is to say that the population is in genetic equilibrium.

The student should now be able to apply the Hardy-Weinberg Law to the generations of mice. Recall that 77% of the F_1 mice were black and 23% white. 77% of the mice must therefore be BB or Bb, and 23% of the mice bb, since the allele for black color is dominant. Knowing the value of q^2 you should be able to find the value of q, which is the frequency of the b allele in the population.

In the hypothetical case of mice, q^2 has a value of 23% (0.23). By taking the square root of 0.23 you get q=0.47. This implies that the frequency of the gene b in the mouse population is 0.47.

Recall from the chart on page 66 that by knowing the value of p or q the student can



The student should be able to show the stability of the gene frequencies in the F_2 F_3 ... by using the checker board shown above. It is important the frequency of gene B and b be used in the determinations.

easily determine the value of the other, since $p + q = 1$. Therefore, the frequency of p in the mouse population is 0.53, or 53% of the alleles in the gene pool are dominant for the black trait. The following two questions can now be answered. How many mice are homozygous dominant (BB) for black coat color? How many mice are heterozygous Bb for coat color? The answer for the former question is $p^2 = (0.53)^2 = 0.28$; and the answer for the latter question is $2pq = 2(0.53)(0.47) = 0.49$. Therefore 28% of the mice in our hypothetical F_1 generation are homozygous BB and 49% heterozygous Bb.

The following chart summarizes the calculations of the distribution of phenotypes in the mouse populations.

Black coat color	White coat color
BB + Bb	bb
$p^2 + 2pq$	q^2
.28 + 2(0.53)(0.47)	.23
.28 + .49	(.23)
.77	(.23)

In this example, the proportion of black coated to white coated mice will remain the same generation after generation. This result indicates that the population is in equilibrium with respect to the above traits.

Exercises for Home, Desk, and Lab (HDL)

Examples: (1 and 2)

(1) If a man with A type blood marries a woman of O type blood and they have 5 children, all of blood type A:

(a) What is the most probable genotype of the man?

(b) What is the genotype of the woman?

(c) Of the children?

(2) A friend of yours has B type blood. He knows his mother has O type blood.

(a) Immediately, you know the genotype of his blood is?

(b) What genotypes of blood might his father have?

With this basic information, find probable solutions to the following genetic problems:

(3) What blood types might possibly result in children of a family whose mother has B blood and whose father has AB blood?

(4) Suppose a father of blood type A and a mother of Type B have a child of type O. What types are possible in their subsequent children?

The student should recognize that heterozygotes allow for randomness of both genes.

(1a) AA

(1b) OO

(1c) AO

(2a) BO

(2b) BB, BO, AB

(3)

	A	*B*
B	*AB*	*BB*
B	*AB*	*BB*

or

	A	*B*
B	*AB*	*BB*
O	*AO*	*BO*

AB, B, or A blood types might result.

(4) AB, A, B, or O

(5)

	B	*O*
O	*BO*	*OO*
O	*BO*	*OO*

Chances of O blood = 50%
Chances of B blood = 50%
Chances of A blood = 0%
Chances of AB blood = 0%

(5) Suppose a father of type B and a mother of type O have a child of type O. What are the chances that their next child will be type O? Type B? Type A? Type AB?

(6) Assuming you do not know the blood type of your future husband or wife but now know yours after the blood typing lab, what blood types might you possibly expect your children to have? What blood types can't they possibly have?

(7) They had their own child. Two type AB parents could not have a baby with genotype OO.

(7) Two type AB parents took home a newly born type A baby from the hospital and decided it was not their baby because it did not seem to resemble either. They claimed another couple had their baby. The other parents were both type A and took home a type O baby. If you were the judge in this case, what would be your decision in this dispute? Why?

(8) (a) No valid claim. Type O blood is impossible from A and AB blood type parents.

(b) Possible heir. Type B blood is possible if B allele of AB parent and O allele of A parent combine.

(8) You are the judge in a case in which a type O man claimed a $50,000 inheritance after the death of type A and type AB parents.

(a) What would be your decision? Explain.

(b) What if the man had type B blood? Explain.

In the following problems, these basic notations will be used:

F_1 means first generation

F_2 means second generation

P_1 means parents of first generation.

Any small case letter means a recessive gene. Capital letters are dominant genes.

Phenotype means the physical or outward appearance of an organism for a particular trait (example: tall, green, or blue-green).

Genotype means the actual two genes of an organism for a particular trait (example: Tt, GG, or bb).

(9) Cross a homozygous black guinea pig with a homozygous white guinea pig and determine the offspring for the first and second generations. Black is dominant.

In the first generation there are ____ black pigs, ____ white pigs, ____ heterozygous pigs. In the second generation there are ____ heterozygous pigs, ____ homozygous pigs, ____ black pigs, ____ white pigs, ____ heterozygous black pigs, ____ heterozygous white pigs, ____ homozygous black pigs.

(9) *4 black* F_1
0 white F_1
4 heterozygous F_1
2 heterozygous F_2
2 homozygous F_2
3 black F_2
1 white F_2
2 heterozygous black F_2
0 heterozygous white F_2
1 homozygous black F_2

(10) L = long-eared
l = short-eared

Phenotypes	*Genotypes*	
4	*0*	*0*
0	*0*	*1*
3	*4*	*2*
1	*0*	*1*

(10) If a homozygous, long-eared rabbit was mated to a homozygous short-eared rabbit, what are the genotypes and phenotypes of F_1 and F_2 if long-eared is dominant?

________________ ________________

________________ ________________

________________ ________________

________________ ________________

Phenotypes:

____ F_1 long-eared
____ F_1 short-eared
____ F_2 long-eared
____ F_2 short-eared

Genotypes:

____ F_1 heterozygous short
____ F_1 homozygous short
____ F_1 heterozygous long
____ F_1 homozygous long
____ F_2 heterozygous short
____ F_2 homozygous short
____ F_2 heterozygous long
____ F_2 homozygous long

(11) W = winged
w = wingless

	W	*W*
w	*Ww*	*Ww*
w	*Ww*	*Ww*

	W	*w*
W	*WW*	*Ww*
W	*Ww*	*ww*

(11) Mate a homozygous wingless fruit fly to a fruit fly homozygous for wings; having wings is dominant. What are the F_1 and F_2 phenotypes and genotypes?

(12) Explain and show how you would make a cross to determine if a tall corn stalk was homozygous or heterozygous.

(13) A lobe-eared man and a non-lobe-eared woman have 8 children of whom 4 are lobe-eared and 4 are non-lobe-eared. What are the genotypes of the man, the woman, the lobe-eared children and the non-lobe-eared children if lobe-eared is dominant? Show your work.

(14) Normal-skinned heterozygous human x normal-skinned heterozygous human--what are the possible phenotypes and genotypes for albinism in their offspring?

(15) Normal pure-bred garter snake x albino garter snake--what are the phenotypes and genotypes of F_1 and F_2 for albinism?

(16) What are the probable genotypes of all people in this cross for albinism?

Albino x Normal
↓
9 Normal Children

(17) What are the genotypes of all people in this cross for albinism?

Normal x Albino   Normal x Albino
Normal x Albino
↓
2 Normal
1 Albino

Students should write out explanations of their phenotypes and genotypes in the crosses.

(12) Back-cross the unknown tall corn with a known homozygous recessive (short). If offspring are all tall the corn was homozygous, but if the offspring are only 50% tall the parent corn was heterozygous.

(13) man = Ll
woman = ll
lobe-eared children = Ll
Non-lobe-eared children = ll

(14) 3:1 ratio normal to albino.

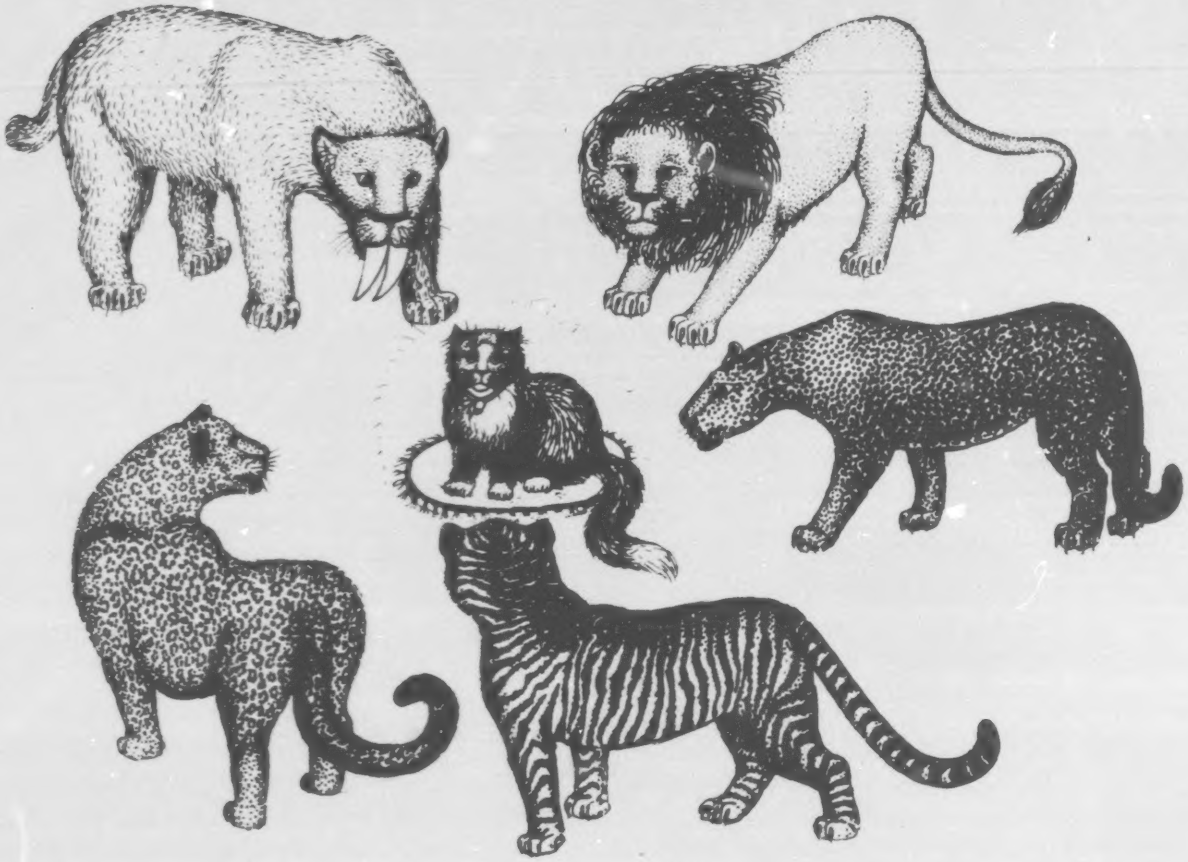
(15) F_1 *= all normal-skinned*
F_2 *= 3 normal-skinned to 1 albino*
F_1 *= all dark (Dd)*
F_2 *= 1 DD:2Dd:1dd*

(16) A = Normal skin
a = albino
aa x AA
↓
Aa

(17) Aa x aa   Aa x aa
↓   ↓
Aa x aa
↓
Aa
aa

(18) 50%	(18) A family has 4 girls. What are the chances that the next child would be a boy?
(19) 1) $q^2 = 1/10,000$ $q = 1/100$ *or 1%* *2)* $2pq = 2 \times 0.99 \times 0.01 = 0.0198$ *or about 2%*	(19) If the frequency of babies born with PKU is 1/10,000, what is the frequency of the defective allele, P, in the population? What is the percentage of normal people who are carriers?

* * *



Chapter III: GENETICS AND CHANGE

The most widespread cause of change in a population is the introduction of new alleles and their different rates of survival. New alleles can enter a population when members of one population interbreed with members of other populations, but if any new allele is traced far enough back, it always can be shown to have appeared suddenly by the change of a gene into an alternative state -- i.e., by the change of one allele into another. Such a change is called *gene mutation*, or mutation, for short.

Mutations are one of the fundamental sources of change in living things. Some mutations are beneficial and some are harmful in a given environment. Mutations from normal alleles to defective alleles are almost invariably harmful. Thus, in humans a change of a normal gene, P, to its defective allele, p, is a harmful mutation since pp individuals can suffer mental retardation. It is believed that all genes have a very small but definite probability of mutating to some other allele. On the whole, mutations are random events and their occurrence bears no relationship to the needs of the organism in which they appear.

References:

Adaptation, Wallace and Srb, Foundations of Modern Biology Series, Prentice-Hall, Inc., 1961.

Genetics and the Origin of Species, Dobzhansky, Columbia University Press, 1951.

Major Features of Evolution, Simpson, Columbia University Press, 1953.

The Meaning of Evolution, Simpson, Columbia University Press, 1949.

Environmental factors can influence the overall rate of mutation of genes. For example, various kinds of radiation increase the rate of mutation, and this is one reason why exposure to x rays is kept to a minimum.

The other major cause of changes in the gene pool of a population is connected with the fact that different invididuals have different chances of surviving and reproducing in a given environment. Biologists say that some individuals are better adapted to their environment, or they say that the environment selects individuals who have certain combinations of genes. This process is called natural selection. Mutation and natural selection go hand in hand, and the result of the two processes is that the population becomes better and better adapted to its environment. If the environment changes, then the population will tend to change also. Given enough time, a species can change into an entirely new species solely by the action of mutation and selection.

Species as used here, implies a population of individuals which are morphologically alike, who can all interbreed, and who do not naturally interbreed or cross with other forms in their environment.

A. - MUTATION AND SELECTION

A very simple model of the operation of mutation and selection is provided by the phenomenon of streptomycin resistance in bacteria. Streptomycin is a powerful antibiotic which rapidly kills ordinary bacteria. However, ordinary bacteria have a gene which mutates at a very low rate to an allele which makes the bacterium completely resistant to streptomycin. Any population of bacteria which is large enough contains one or more streptomycin-resistant bacteria. In the absence of streptomycin, ordinary bacteria have what is called a selective advantage because ordinary bacteria grow faster than streptomycin-resistant bacteria. On the other hand, in the presence of streptomycin, streptomycin-resistant bacteria have an enormous selective advantage since all other bacteria are killed. Notice that a given allele may be beneficial or harmful depending on the environment.

It is easy to select the streptomycin-resistant bacteria in a population by exposing it to streptomycin; it is more difficult to prove that the resistant bacteria arose by random mutation and were already present in the population before it was exposed to streptomycin. In the following experiment we will confine ourselves to the easier problem.

During this experiment there are two periods of waiting for the bacteria to incubate. It is reasonable to get a lot of the paper and pencil exercises done during this time.

1). Escherichia coli is a natural inhabitant of the human intestine.

2). Streptomycin is not harmful in this dosage. However, neither is it suitable for self-medication.

3). Check to see if the E. coli you get is susceptible to streptomycin.

A.1 - Experiment: STREPTOMYCIN RESISTANCE

Obtain two cultures of bacteria from your teacher. Using the technique demonstrated by

Materials and Equipment

Difco Nutrient Agar
Streptomycin sulfate (2% solution)
Difco Nutrient Broth
Sterile plastic petri dishes

Sterile cotton
Sterile test tubes
Sterile pipettes
Inoculating loops
Slant of Escherichia coli

If the streptomycin is not sterile, add a few drops of chloroform. DO NOT AUTOCLAVE.

After the nutrient agar is sterilized, it should be held at 45°-50° C to keep it melted until use. The streptomycin should be added to the melted agar after it has cooled to 50°. Add 1 ml streptomycin per 100 ml agar.

The cultures provided to the students should consist of 5 ml of nutrient broth in a 125 ml erlenmeyer or in a test tube inoculated from the slant and incubated 18-24 hours at 37° C.

It is possible you will need to do this procedure more than once; strep-resistant E. coli is here.

(1) The proportion should be about one resistant cell per 10^9 normal cells.

(2) The variation should be much greater than ordinary sampling error because the proportion of mutants depends on how early or late in the history of the culture a mutation occurs. If a mutation occurs early, the proportion will be extremely high because there will be many descendants of the original mutant. Such a culture is called a "jackpot" culture.

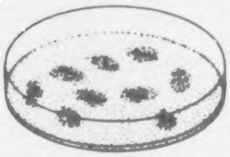
your teacher, pour the cultures into separate petri dishes. Label one dish "without streptomycin." Carefully pour about 25 ml of streptomycin agar into the streptomycin petri dish and swirl the dish to distribute the bacteria. Do the same to the other petri dish using the agar without streptomycin. Allow the agar to solidify. Incubate the petri dishes at 37° C for at least 48 hours. Examine the petri dishes for signs of bacterial growth by holding them up to the light. The dish without streptomycin will show an almost opaque haze of bacteria while the dish with streptomycin will have only a few isolated colonies, consisting of streptomycin-resistant bacteria. Each colony arose from a single resistant bacterial cell which was present in the original population. If we assume that the original culture contained 2×10^{10} individual cells, what is the proportion of resistant cells to normal cells? Compare the number of resistant colonies in your streptomycin dish with the number obtained by other students. Can you suggest a reason for the wide variation in number of resistant colonies from one culture to the next?

Make two more agar plates with streptomycin. Select a colony of cells from the streptomycin plate and spread it on one of the new plates.

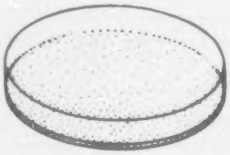
Spread a film of cells from the plate without streptomycin onto the second new plate and incubate for 48 hours.

What do you think will happen when the plates are incubated for 48 hours? It seems evident that we can select pre-existing traits to be perpetuated.

A film on this subject, "Natural Selection," EBF, is available. Treated are two topics, black vs. white moth survival and DDT-resistance in mosquitoes.



With S



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B. - ARTIFICIAL SELECTION

B.1 - Investigation: DEVELOPMENT OF A NEW BREED OF DOG

Another study which may be of interest is reported in "Pigs in the Laboratory," Scientific American, June 1966, pp. 94 ff.

In the following pages an account is given of the application of the principles of genetics to a specific problem - the development of a new breed of dog which has certain desired characteristics. In this process, man plays the role of a selective agent. Furthermore, instead of selecting those desirable combinations of characteristics which appear only by chance, man consciously chooses mating pairs so that the process is greatly speeded up.

At first, several types of dogs were crossbred until the desirable traits were assembled in one line of descent. However, crossbreeding increases variability (why?), and in order to "fix" or stabilize the new type, it was necessary to inbreed for several generations. The term inbreeding refers to mating close relatives. Why does inbreeding tend to stabilize genetic characteristics?

It increases frequency of homozygous gene pairs.

Current studies at the University of Oregon Medical School provide the information used in this section.

"New Canine Breed Claims Distinguished Ancestors," from Imprint, (University of Oregon Medical School, Winter, 1967).

A good student activity might involve trying to "Draw the Dog" with a field-trip or visit to decide the winner.

The decision to try to develop a new breed stemmed from the need for a medium-sized standard laboratory dog for use in organ transplantation, shock studies, and gastric physiology. Small animals have been inbred and studied until it is now possible to obtain healthy uniform animals of known age, weight, sex, genetic background, and characteristics. But investigators requiring larger animals are forced to use pound dogs of completely unknown genetic background, age, and health.

Several colonies of purebred dogs have been developed throughout the country for use in specific projects. These include the Beagles for radiological research and drug testing and a number of other breeds for nutritional, developmental, and behavioral studies. Despite this, no well conceived long term project to develop a larger laboratory dog has been undertaken.

The Oregon team's first step was to decide which traits such a dog should have. They decided upon these specific characteristics: genetic uniformity, large litters, early maturity, stress resistance, 35-40 pound size, easy to care for, gentleness, trainability, short hair and light skin (for dermatology studies), short or curly tail (grooming and cage cleanliness), quietness, and cage tolerance.

First they studied various existing breeds to see if any met these established criteria.

Interest in the Fox Hound was offset by the fact that they were almost nonexistent on the Pacific Coast.

The animal care team found that the Bull Terrier, or Pit Bull as it is often called, has many characteristics they were looking for - short hair, weight about 50 pounds, broad chest, and a relatively short tail. But the disposition of the breed worried the researchers. Historically, the Bull Terrier was bred as a fighting dog and the team felt they might face problems if they housed more than one dog to a run.

When their search failed to turn up an ideal dog among existing breeds, they began choosing the purebred stock to use in developing a new breed.

They found the Labrador Retriever had more of the desired traits than any other of the readily available breeds. The Labs originally came from the West Coast of Newfoundland, where they were prized as fearless water dogs and retrievers as early as the beginning of the 19th century. This was a good trait for Oregon's damp climate.

Selected specimens of the breed had been taken by trading vessels to England, where most of them were bought by wealthy persons to breed and use as retrievers. Standards were set and the breed carefully improved by vigorous culling. As a result, almost all pedigreed Labradors can be traced to a very few well-known dogs.

Furthermore, the Lab is the only breed which cannot be made a bench champion without at least a working certificate in the field. This means they must retrieve ducks and pheasants under fire. As a consequence, they have never been bred indiscriminately for conformation without regard to strength, endurance, temperament, intelligence, and trainability. The outcome of these partly fortuitious and partly far-sighted occurrences is that many of the best specimens of the Labrador have very high coefficients of inbreeding and yet have not lost the admirable qualities for which they are well-known.

At about the same time the Lab was chosen as the base breed in the Oregon program, a prominent Portland woman whose hobby was breeding top Labs decided to close her kennel. The Medical Research Foundation of Oregon purchased these dogs for the Medical School. This was particularly fortunate, as they were able to start the colony with some of the country's finest stock.

While generally quiet the Lab is not "barkless," nor does it have a short or curly tail. In an attempt to obtain these traits the "barkless," curly tailed African Basenji was chosen to cross with the Labs. Actually the Basenji is not mute but it seldom barks, and its vocalization comes out more like a chortle or yodel.

Pictorial evidence indicates that these dogs were known in Egypt five thousand years ago yet the breed has apparently changed very little since that time. On engravings in tombs dated 3600 B.C., the Basenji is shown as a house dog, attached to the chair of the master. From the time of ancient Egypt until the middle of the 19th century, Basenjis faded into obscurity, although evidence shows that deep in Central Africa, away from Mediterranean civilization, they were valued and preserved. Then around 1870 explorers returning from the Dark Continent spoke about these unusual dogs.

The first Basenjis are reported to have been brought into the United States about 1937, and the breed was given American Kennel Club recognition in 1943.

Unlike most male dogs, the Basenji is capable of breeding only during a short period each year, usually from September to December. The Medical School hopes to overcome this drawback by establishing a frozen sperm bank for artificial insemination.

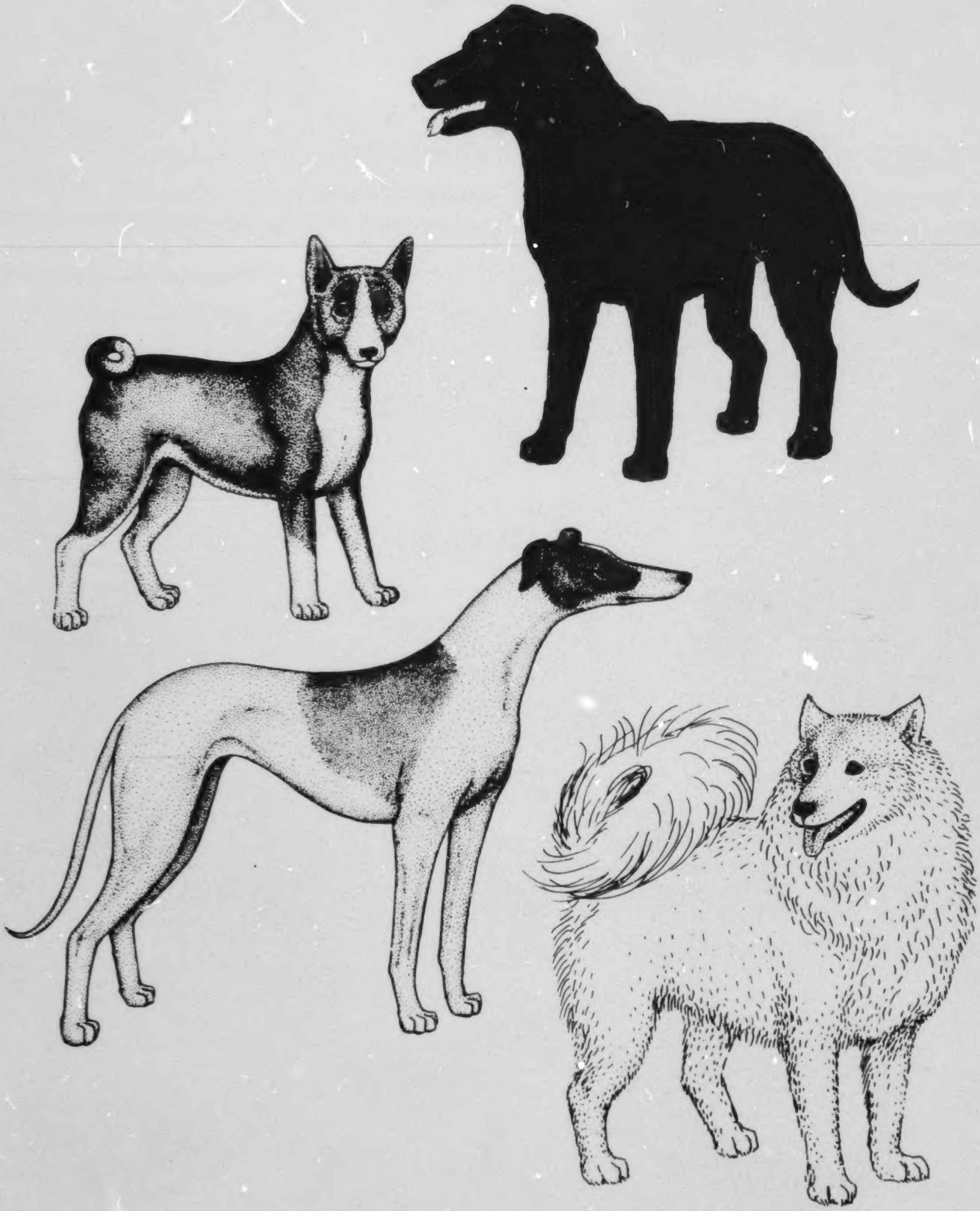
The results of these Lab-Basenji breedings were encouraging to the UOMS team. Most of the pups had some curl in their tails and tended to bark much less than the purebred Lab pups.

Next, to retain size, further develop the curly tail and broad chest, and try for lighter skin, another historic breed--the Samoyed--was introduced into the line.

Since the Lab is a relatively new breed, the group felt it was important to include ancient breeds with a background of hundreds of years of pure breeding and consistent genetic background for the remainder of the breeding stock.

The Samoyed gets his name from the partly nomadic Samoyed tribes of northwest Siberia. For centuries the Samoyed has been the faithful servant of his primitive owners. Sled dog, guard dog, shepherd of reindeer, the Samoyed is energetic and tireless. He is capable of pulling one and a half times his weight even under the most difficult conditions of weather and terrain.

The fourth and final breed chosen was the Greyhound, another of the breeds that has an authentic history of over 5,000 years. This dog has long been associated with royalty. Under the laws of Canute, King of England and Denmark



in the eleventh century, no person below the rank of Gentleman was permitted to own a Greyhound. Its popularity in many countries for thousands of years is apparent by the numerous carvings, statues, paintings, and tapestries showing it in the company of kings, nobles, and huntsmen.

Its short, smooth, firm-textured coat, its stamina, and its weight of around 65 pounds favored its inclusion in the program. But more important for a research breed, the Greyhound has very large blood vessels.

The dogs developed as breeding stock are about 40% Labrador Retriever, 40% Basenji, 10% Greyhound and 10% Samoyed.

The project is developing well, with each generation showing more and more of the desired characteristics. By now the researchers can predict success. Within a few more generations they expect the new type of dog to breed relatively true (i.e. be homozygous for most genes).

Detailed records are kept on each dog in the breeding colony, including when the bitches' oestrous cycles occur, how long they last, and the number of puppies per litter. Nutritional, environmental, and genetic background is maintained on all dogs.

Records on puppies born in the colony rival those pediatricians keep on babies. Pups are weighed once a week for the first 12 weeks, then once each month until they reach maturity. To establish a base line blood tests are done on each pup every three months.

When the pups are eight weeks old they undergo a series of weekly tests which were designed by Guide Dogs for the Blind. These tests include such tasks as fetching, sitting on command, following moving objects, and coming when called, as well as the observations of their response to noise, to being put on a wire-mesh floor, to having their ears and toes gently pinched, and their tails petted. Results of the these tests, showing which of the pups are most intelligent, best tempered, and most sensitive, assist the animal care team in planning future matings.

Because a dog's future reaction to humans is determined by its experiences at three to twelve weeks of age, all personnel at the farm are encouraged to handle and play with the young pups as much as possible - a chore that takes little urging.

At six and nine months the young dogs are graded according to the established standard of desired characteristics. The team is encouraged with over-all results to date. Dogs of the newly developing breed bark very little, their tails are beginning to curl, their hair is short, the skin is fairly light, and socialization with humans is good.

The public relations aspect of such a dog breeding program was demonstrated recently when one of the nation's leading dog clubs, the Ventura County (California) Dog Fanciers Association, sent the School a check in support of the program. Association President Jim Henderson said,

> "The importance of dog-breeding programs to dog lovers lies in the fact that the faster animal research colonies around the country become self-sustaining, the less will be the schools' need to depend on dog dealers or to buy pound animals. Those men who steal dogs to sell to unknowing research institutions will be forced out of business, because there will no longer be any market for their animals."

Commenting on the gift the team leader said,

> "To my knowledge this is the first time such a group has done this. This is most encouraging to us in the field who are vitally concerned with providing healthy animals for medical research and giving these animals the finest care possible."

B.2 - OTHER EXAMPLES OF ARTIFICIAL SELECTION

Man has been using procedures like this for a long time--selecting the parents of future generations. Horses have been selected for speed, power, or appearance; various breeds of dogs have been developed for varying traits. Man has improved corn so much that it has developed from about 50 kernels per ear to what you now find in grocery stores with about 50 kernels per row.* All our commercially grown fruits and vegetables are the products of selection. Wild types of citrus fruits, for example, when compared to cultivated types are found to have thicker, coarser skins, less juice, and far more seeds. In Oregon, agriculturists have developed many fine kinds of cane berries based on the old, wild blackberry.

C. - DEVELOPMENT OF THEORIES OF CHANGE

The question of how such new forms may have arisen without the aid of man has stirred the scientific community for years. In western culture the concept of evolution is at least as old as the Greeks. Before Darwin's time men of the scientific community had constructed models to explain the mechanisms that produce change. However, evolution models before Darwin's proved unsatisfactory.

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*With all this improvement, corn has lost the ability to survive. Without man to strip away the husks and plant the seeds, it has been predicted that extinction would occur in approximately 5 years.

One theory was proposed by Jean Lamarck in 1800. He believed that traits, such as the giraffe's long neck, can be inherited in a form which has been modified by use or non-use. For instance a giraffe who reached for years to get the higher leaves from trees would elongate his neck muscles and would pass on this trait (elongated neck) to his offspring. The same sort of development is seen in the body of a person who exercises and works with weights in a body building program, except that according to Lamarck the children of this person would be born with a physique better than normal. It seems obvious that this is not a satisfactory model.

C.1 - DARWIN AND NATURAL SELECTION

As naturalist and ship's physician on the Beagle, Darwin circled the world on a two-year trip. The ship was making charts of harbors all over the world and sometimes laid over for a month or more in port. During such port calls Darwin was able to observe and collect many kinds of plant and animal specimens. Included in their stops were the Galapagos Islands on the equator 600 miles west of Ecuador. Here he collected many bird skins and skulls. Among the very few kinds of birds on the islands were a variety of

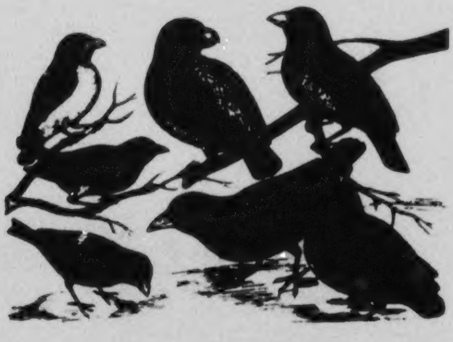
A filmstrip, Galapagos, Enchanted Isles, Life filmstrip, should be used to share the Beagle adventure.

If you wish to quantify the bill differences variation can be expressed in many ways:

1. ▷ the angle of the beak tip.

2. ▷ the area of the beak profile (a = ½bh).

3. ↕▷ the ratio of depth to length--this is the scientists selection.

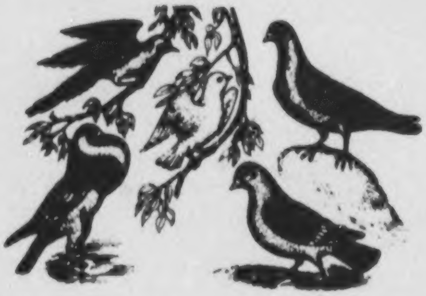


finches, which proved to be key organisms in Darwin's developing the Theory of Natural Selection.

A remarkable feature of the finches is the extreme variability of their size and the shapes of their beaks. They could easily be classified as large, medium, or small. Their bills could be described in terms of shape--conical ▷ to sharp ▷ with gradations in between. Another characteristic which could be classified was their food-gathering behavior. Some ate seeds from the ground; others, seeds from the bushes and trees, before they fell to the ground. Some of the birds ate cactus seeds and yet others mainly used insects as food.

This diversity in an assembly of birds similar in so many ways was fascinating to Darwin, and although his Journal makes no mention of it, he may have been thinking about the origin of new kinds as his collection was being made. He hypothesized that a group of finches had been blown to the Galapagos from the South American continent by a freak wind or storm. With few natural predators, they reproduced prolifically. Finding a home with a large variety of available food and few other kinds of birds to compete with, many of the variants which had been unable to compete successfully on the mainland survived on the islands. The diet(s) of the birds regulated their chances of breeding with a suitable mate, i.e., male and females eating cactus seeds would be more apt to meet and possibly mate. At any rate, the food eaten and the bill shapes have become effective in keeping the many groups of finches isolated from each other, so far as mate selection is concerned. This has perpetuated bird sizes and bill shape variations which would not have survived on the mainland.

Have new kinds of birds evolved in this process? Darwin had no satisfactory answer to a question such as this, yet, if originally all finches had one size of bill, how did there ever come to be any variation at all? Hugo de Vries introduced a term which we still use to describe the sudden appearance of a brand new trait; he called them mutations.



One of Charles Darwin's experiments was to crossbreed existing varieties of domestic pigeons and rebreed the mixed young. After a period of several generations he had birds which could not be separated from the wild rock doves living in the area. He felt this supported his idea that man, over an extended period of time, had bred special birds with specific traits which he admired, to arrive at the particular breeds which now exist. He spent many years gathering all kinds of data which contributed to his theory that selection occurred in natural situations.

When published, Darwin's model of the evolutionary mechanism seemed simple and was general enough to answer most of the questions asked. It was called the Theory of Natural Selection. The theory requires that the following assumptions be true:

1. That organisms have the potential to produce surplus populations.

2. That variation exists within the population.

3. That new or alternative traits have the ability to be passed from a generation to its descendants.

Most of the ideas incorporated in Darwin's Theory of Natural Selection were based on the works of previous investigators. Darwin's major contribution was recognizing the role that selection plays in the evolutionary process. He visualized selection as functioning as follows: In a population with overproduction of young, those which are most likely to survive and have young of their own are those which are best adapted to survive. If they can pass their traits on to their young, these traits are going to appear in the population more often than the traits of those which are not as well suited to survive. In the face of a changing environment, this would result in an eventual shift of the population to new behaviors or structures or both. This shift or change in the characteristics inherited by successive generations is another definition of evolution.

C.2 - FOSSIL EVIDENCE OF CHANGE

Change in a population is a slow process which ultimately results in one or more new kinds. A slow process--How slow?

Let's look at a different organism--the horse. In the fossil history of the horse there have been many trends: general increase in size, distinct change in eating habits, and specialization toward fewer toes. Inferences based on skeletal proportions indicate that increased running speed has not been a trend. An index of the growth trend may be seen in a measurement of part of the skull: the teeth

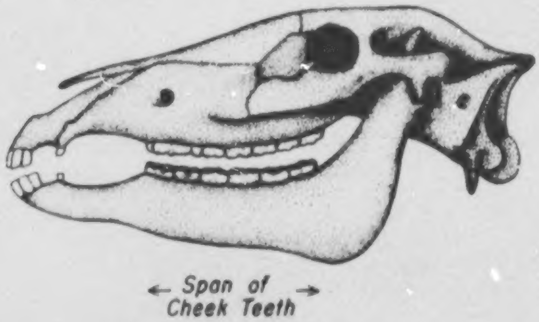
The instructor may be interested in using geologic data in developing an evolutionary picture of different life forms. The following films and film strips are recommended for such an approach.

In the Beginning, Modern Talking Pictures.

The Triumph of the Dinosaurs, Life Filmstrip.

Mammals Inherit the Earth, Life Filmstrip.

Prehistoric Animals of the Tarpits, Film Associates.



HORSE SKULL

Figure C.1

Lava and the River, Martin Moyer film, 20 min., color.

Story in the Rocks, Shell Oil, 17 min., color.

are often the best preserved part of a fossilized organism so the largest sample of data can be drawn from measurement of teeth.

Using the information on the following page, make a graph showing the pattern of growth in span of cheek teeth over the past 60 million years.

	Kinds of Fossil Horse	Average Span of Sample Cheek Teeth in cm	Approx. Age-10^6 yrs.
1.	Hyracotherium	4.3	60
2.	Orohippus	4.3	53
3.	Epihippus	4.7	45
4.	Mesohippus	7.2	40
5.	Miohippus	8.4	39
5.a	Miohippus	8.3	33
6.	Parahippus	10.0	30
7.	Merychippus	10.2	20
7.a	Merychippus	12.5	15
8.	Pliohippus	15.5	10
8.a	Pliohippus	15.6	7
9.	Equus	18.8	5
9.a	Equus	17.6	1

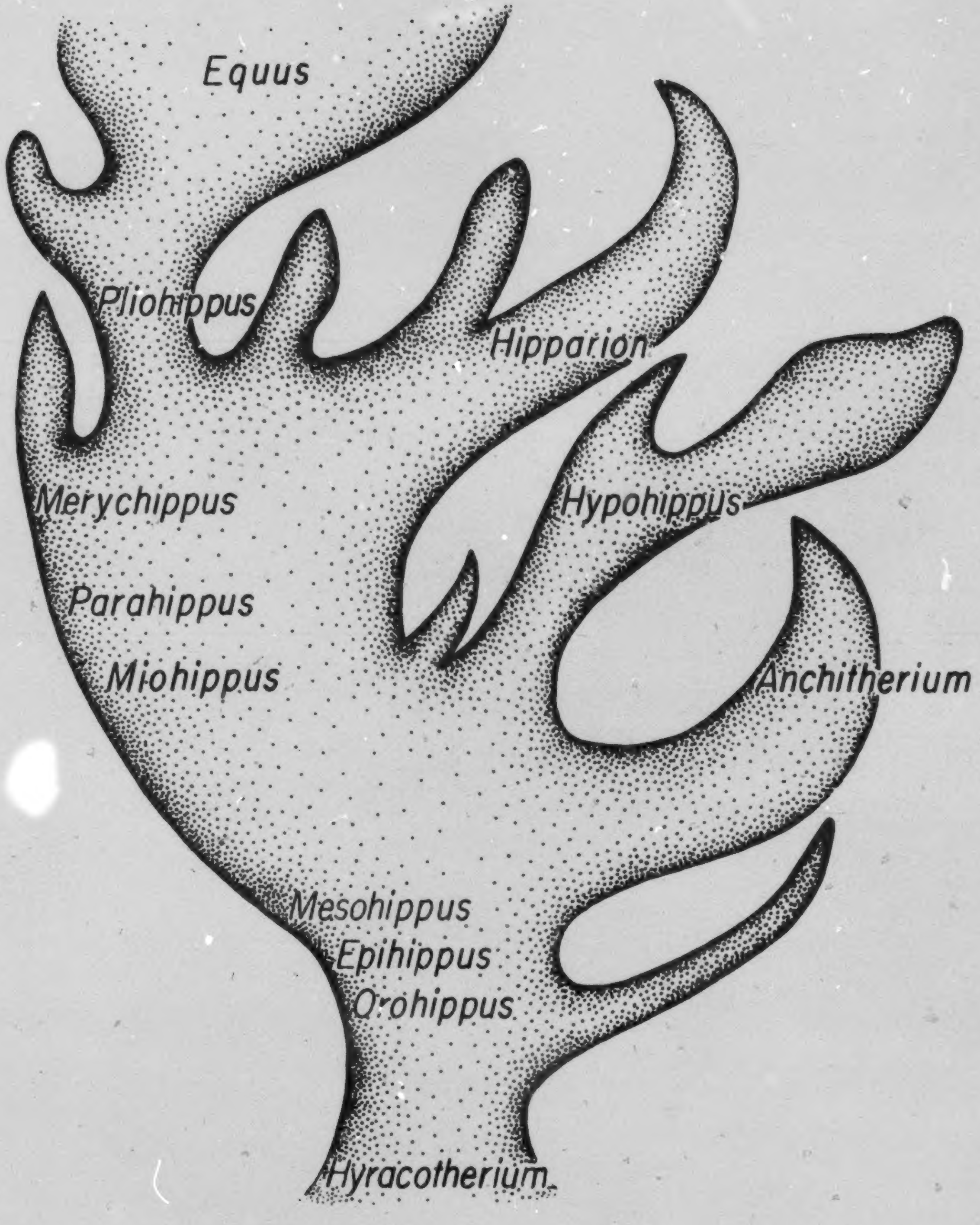
1. Describe the changes from Hyracotherium to Epihippus.

   a. What is the total change?
   b. How long did it take?
   c. What is the rate of change per million years?

2. Describe the changes from Miohippus to Equus.

   a. What is the total change?
   b. How long did it take?
   c. What is the rate of change per million years?

3. Is the rate of change constant?


Equus
Pliohippus
Hipparion
Hypohippus
Merychippus
Parahippus
Miohippus
Anchitherium
Mesohippus
Epihippus
Orohippus
Hyracotherium

HORSE FAMILY TREE

Exercises for Home, Desk, and Lab (HDL):

Sickle cell anemia is a disease that is characterized by low hemoglobin, oxygen insufficiency, and lethargy. The disease is caused by a mutated gene and results in the red blood cells taking on a cresent shaped form. (The normal form of a red blood cell is biconcave). When the mutated gene is homozygous in an individual, sickle cell anemia results and the person generally fails to live long enough to reproduce. Individuals with the mutated gene present in the heterozygous condition are unaffected by anemia, but sickle cells can be observed in a blood smear.

Sickle cells are found predominantly in Africa among members of the Negroid races. Scientists studying the disease found the sickle cell trait to be prevalent in areas endemic for malaria (a disease caused by a protozoan parasite and transmitted by female mosquitoes). Attempts were made to establish some kind of correlation between the incidence of malaria, the sickle cell trait, and the environment. Consider the following data and answer the questions posed.

In a village with a high rate of sickling, this data was recorded:

	with malaria	malaria-free
children with sickle cell anemia	12	31
normal children	113	134

1. 290	1. How many children were examined?
2. 43	2. How many had sickle cell trait?
3. 125	3. How many had malaria?
4. $\frac{125}{290} = 40\%$	4. What is approximate % total children with malaria?
5. $\frac{12}{43} = 30\%$	5. What is approximate % sickle cell trait children with malaria?
6. *This is debatable; it should raise further questions.*	6. Does sickle cell trait prevent malaria?
7. *Develop the concept of Natural Selection here.*	7. Hypothesize as to the role of the sickle cell trait and the spread of malaria.

A controlled experiment resulted in the following data:

A group of 30 volunteers was assembled, 15 with and 15 without the sickle trait. All 30 were free of malaria and all 30 were injected with the malarial organisms. The table below shows the results.

Sickle-trait vs. Malaria Experiment

	sickle cells	normal (no sickle cells)
injected	15	15
contracted malaria	2	14

1. What % sicklers got malaria?	*1. 14%*
2. What % normal got malaria?	*2. 93%*
3. Does sickle cell trait protect against malaria?	*3. There is some evidence that it does.*

Chapter IV: POPULATIONS

We have discussed techniques of change as they affect both individuals and groups of individuals. Now let us examine more closely that group which the biologist calls a population. A natural starting point will be the mice we have been working with over the past weeks.

A. - A MOUSE COLONY AS A POPULATION

A.1 - NUMERICAL PREDICTIONS

Read these questions over with care. See that you have the information you need to answer them.

1. How long have we been working with the mice?
2. How many female mice do we have?
3. How many of the females eventually had a litter of pups?
4. How many mice do we have now?
5. How many mice were lost or have died?
6. How many mice would we have if there had been no losses?
7. What has been the average daily increase in the mouse colony?

There is need to help the student build the concept of population. Recall that a population is defined as all the organisms of the same kind in a given place at a given time - e.g., the horses of the Willamette Valley, 1885-1900.

The mice can be used in building this concept. The questions listed are designed to bring the concept out of the students' experience with the mice.

The students are asked to make four predictions based on data previously gathered. The teacher might group students to work on different predictions at one time.

Populations and how they change is the topic. . .There are skills of graphing and interpretation involved. The effect of over-population is the message.

8. Prediction 1: Based on average daily increase in mouse count, predict the number of mice in the colony at the end of a year if this rate continued.

9. What has been the time between generations, in days?

10. What is the average size of a litter?

11. How many females to the litter?

12. Prediction 2: Using the accumulated mouse colony data, predict the potential mouse population if the colony were allowed to build for a full year. (Assume no losses.)

13. What is the average number of pups per litter surviving to be weaned?

14. Prediction 3: Predict a year-end population if losses are considered.

15. A bacterial cell under ideal conditions reproduces every 20 minutes (one cell becomes 2 cells). If a scientist leaves one in his lab (under ideal conditions) for 48 hours, how many bacterial cells will he find?

15. 2^{144} *or* 1.6×10^{43} *cells.*

16. A bacterial cell masses 1×10^{-12} grams. Calculate the mass of the population in problem 15.

16. $\left(1 \times 10^{-12} \frac{gm}{cell}\right)\left(1.6 \times 10^{43}\ cells\right)$

$= 1.6 \times 10^{31} gm$

$= 1.6 \times 10^{28} kg$

17. Does this most closely resemble the mass of a fly, dog, man, whale, or the earth?

17. Approximately the mass of the earth.

6×10^{24} *Kg*

18. Prediction 4: Starting with four mice as we did, the potential mouse population is very large. A more reasonable estimate recognized that not all pups survive (see 14). Out in the real world the mouse population right now is many more than three or four. Do you predict a tidal wave of mice next year? Why?

A.2 - BIOMASS OF THE MOUSE COLONY

The data you have been gathering on the changes in mass of the mice and the masses of food and water in-put will now be put to use. We will look at the growth of the mouse population in another way.

Make a graph to show the following:

The mass of the mice over a period of time.

Best period of time to use is the time since the colony was started.

The mass of food used per day over a period of time.

The volume of water they use per day over a period of time.

Do the mass of the colony, the food they eat, and the water they drink show the same pattern of change?

The pattern is or should be similar. It should be a smoother curve than the increase in numbers; it will not show plateaus. You may want some students to plot this data on semi-logarthmic paper.

Predict the mass of the colony at the end of a year of unrestricted increase. Predict the weight of food they would then require.

Is the pattern of increase in mass the same as the pattern of increase in number?

B. - A MULE DEER POPULATION

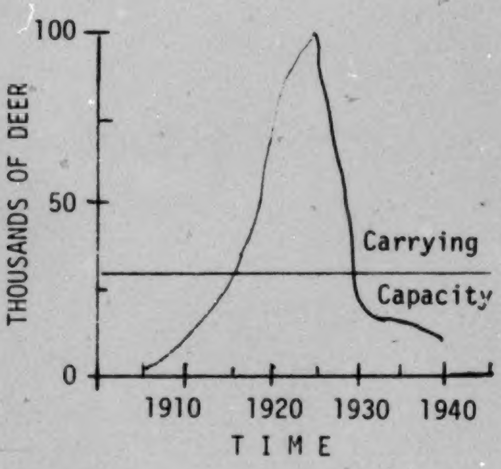
This data was gathered over a period of years on the Kaibab Plateau, an area of about 700,000 acres of isolated pine forest on the north rim of the Grand Canyon. It represents counts and estimates of the population of mule deer living there from about 1900 to 1940. Plot this information on a graph.

Date	Thousands of deer	
1905	4	Established as a Game Preserve
1910	10	
1915	25	
1920	68	Predator eradication program from 1907-1923
1925	100	
1930	19	
1935	15	
1940	10	

Game management personnel have studied the Kaibab Plateau and determined the maximum carrying capacity of the land to be 30,000 deer. What do you suppose carrying capacity means in this sense? Why are there fewer deer on the Kaibab Plateau than 30,000?

A program has been established in which predators which need to be eliminated from other places are captured rather than killed and a portion of them are moved to the Kaibab to help reestablish and maintain the balance between predator and prey.

The graph will show a very classic pattern of population growth and decline:



Carrying capacity is the maximum mass of a kind of organism which can be supported by a given piece of land. It may be related to food available or appropriate nesting sites or places to hide.

Probably the land had not by 1940 reestablished its full carrying capacity or the predators have been doing an excellent job of controlling the deer population.

C. - HUMAN POPULATIONS

The Kaibab mule deer are regarded as a classic population, showing development and decline. How does the population of man compare? Are there similarities?

C.1 - Experiment: HUMAN POPULATION

Populations are not static. One would hardly expect the number of people in Portland to be the same today as it was twenty years ago or as it will be twenty years from now. The population of this classroom changes from hour to hour and day to day. But by observing past populations, we can often make reasonable predictions about the future.

Students may need help with the term predator. Mountain lions and wolves are examples of hunting carnivores.

Deevey - "Human Populations"

Scientific American Offprint # 608

Man has only an increase phase so far.

Two films are highly recommended: E.B.F., Population Ecology (21 min.) Two experiments are recapitulated. Fruit flies and mice in limited space and the problem of birth rate vs. death rate vs. increase in food production through modern technology are exposed.

Shell Oil, Food or Famine (26 min.), traces the problem of food production and considers the changing carrying capacity of the earth in favor of man.

This is largely a lesson in graphing and extrapolation. It carries a message about population explosion. You can expand it to include logarithms if you wish. Using semi-log paper helps straighten out the line on a graph.

Population data (world wide) is given only up to 1950 in order that they will be forced to make predictions, some of which can be easily checked. Almanacs of various sorts include detailed information about the U.S. population from colonial times to the present. Many small details can be examined if time permits and the students seem eager to continue.

To illustrate, look at the data provided and attempt to visualize what the numbers mean. A time versus population graph will make the data clearer. The data will need to be analyzed and/or interpreted in order to be useful. You may be asked to make predictions about the future of the human population.

A million-fold change in the population makes semilogarithmic treatment mandatory. Almanacs often go into great detail in explaining the assumptions made in projecting future populations.

- - - - - - - 1960 - - - - - -

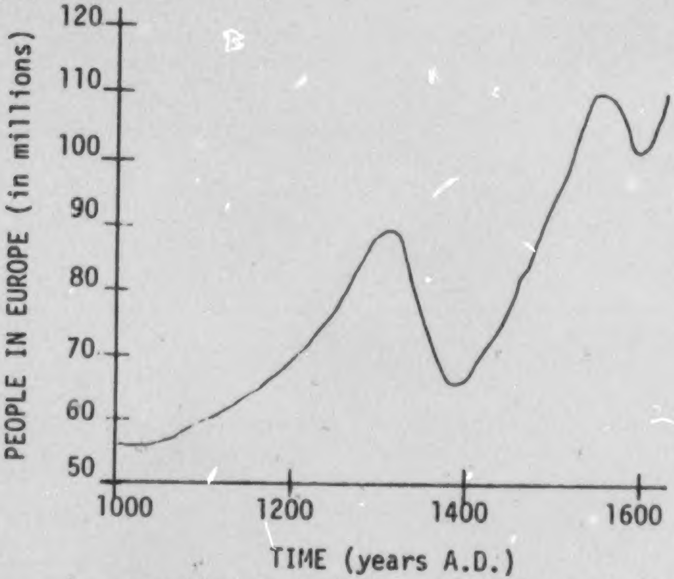
Africa	*Asia*	*Europe & USSR*	*Pac. Isl.*	*World*
244×10^6	$1{,}665 \times 10^6$	641×10^6	16.4×10^6	$2{,}972 \times 10^6$

Estimates of World Population (in millions) by Regions,
1650 - 1950

Date	Africa	Asia (exc.) U.S.S.R.	Europe and Asiatic USSR	Pacific Islands	World Total
1650	100	257	103	2	470
1750	100	437	144	2	694
1850	100	656	274	2	1,091
1900	141	857	432	6	1,571
1920	150	967	486	8.8	1,810
1950	199	1,376	575	13.2	2,493
Area (in Km^2)	3.02×10^7	2.75×10^7	2.73×10^7	8.5×10^6	1.36×10^8

C.2 - EUROPEAN POPULATION, A.D. 1000 - 1600

Study the following graph on European populations.



Are graphing techniques used which tend to confuse or mislead the reader? If you think so, list as many as you find.

Write a word interpretation of the graph.

The graph does not start at 0 or the advent of man. The big dips are two major outbreaks of the "Black Death."

Note previous page; time jumps in data are not the same size. Graphs should reflect this . . .

D. - THE EFFECT OF DENSITY ON POPULATIONS

What is the floor area of the cages housing the mouse colony? With three mice in it, what is the area available per mouse? Express this as mice per 100 cm^2. With a mother and litter in the cage, what is the area available for each mouse? Express this as mice per 100 cm^2. The number of mice or the mass of mice per unit area is referred to as the density of the population.

Density or space available is one of many forces which influence the rate of change in a population. The number of square miles in the U.S. did not change appreciably during the years 1920-1950 but our population density did. What was the change in U.S. population density, 1920-1950? The world population density? Human population density is often expressed as number of people per square mile.

U. S. Population Data:

1920	106×10^6
1950	151×10^6
1960	179×10^6
1968	$200+ \times 10^6$

Area = 3×10^6 *sq miles*

D.1 - Investigation: THE EFFECT OF CROWDING ON POPULATIONS

The state of Oregon keeps track of campground use in terms of camper nights. Use these figures to answer the following questions:

Year	Campground use in camper-nights
1960	595,023
1961	708,210
1962	842,408
1963	877,658
1964	1,003,881
1965	1,127,928
1966	1,307,121

How long has it taken us to double the use of park camping facilities? How long will it take to redouble the use?

About 5 years

About 5 years

Some experts project that at the present human population growth rate, every square foot of land surface will be covered by people in six hundred years. It has been suggested that the only way to house this fantastic population would be to have 2,000 - story buildings.

However, experience has shown that populations do not grow and grow to infinity. Rather, a steady state is ultimately reached where the number of individuals entering a population is balanced by the number leaving. To reach a steady state either the birth rate must decrease or the death rate increase. Ignoring the frightening prospects of future population levels, we have a problem today - hunger. Most nations of the world are pressed for food. We will not have to wait for the year 2,000 to see people starving; widespread famine is predicted by 1975. Some experts have called hunger the second hydrogen bomb. Starvation today takes a high annual toll of lives on a world-wide basis.

Some topics for investigation involving other potential warnings to man are studies of social deprivation in monkeys and dogs.

Sci. American Offprints are a good source.

Scientific American Offprint # 506, Calhoun "Population Density and Social Pathology"

D.2 - EFFECTS OF CROWDING IN MICE

The size of any population is related to four factors: birth and death rates and immigration and emigration. The reason for an individual's death or migration is incidental; the important idea is that he is no longer part of the population, and the population has undergone change.

It seems to be true that natural populations eventually stabilize and establish an approximate balance between input and outgo of numbers or mass.

In an experiment, a constant supply of mouse food was provided on the main floor of an abandoned building. Each day, there was an established amount of food available for mice to eat. It was soon apparent that the population of mice in the building was growing (birth and immigration). As the population went up the food supply became inadequate, and hunger forced the mice to increase their foraging range. Some of the mice in foraging no doubt found greener pastures. At any rate, with no apparent increase in the death rate the population declined.

The building was then sealed (mouse-proofed) and the mice inside could no longer emigrate. How would they respond when the constant food supply became inadequate? They responded with a decrease in the birth rate, and after a period of time, it was unlikely that any of the mice were starving to death.

When the food supply was changed to provide abundant food regardless of the number of mice eating, the birth rate adjusted upward. The mice were still restrained to the boundaries of the building and space became a factor in the population size. The pressure on the population finally resulted in a kind of stability in which the mice died much younger largely due to litter desertion by the mother and cannibalism.

When a similar experiment was conducted elsewhere, the population changes were nearly the same, but the adjustments in rate were not the same. Rather than a change in the death rate, the stability was arrived at by very noticeable changes in birth rate.

In an American Institute of Biological Sciences meeting at the University of Colorado, Stephen H. Vessey presented a significant paper. He wrote of the socio-physiological mechanisms which were discovered working in animal populations. Vessey found that crowding in mouse populations results in an increase in the size of the adrenal gland (a pale yellowish gland on the upper end of each kidney, which secretes several important hormones, including adrenalin). These hormones interfere with the substances in blood that fight infection and disease. It seems obvious that if resistance to infection decreases as a population increases, crowding directly increases morbidity (disease and death) in populations. In an experiment to test this idea, Vessey injected mice with beef serum, a substance that normally stimulates the production of antibodies (disease fighters) in animals. The mice were then tested for the antibodies present in the bloodstream. The mice living in groups were found to have fewer antibodies than mice living alone.

In another experiment, mice were tested for their resistance to tetanus. Some of the mice had been living in groups, while others had been isolated in jars as controls. When all mice were injected with tetanus poison, 33 of the 40 crowded mice died but only 11 of 30 isolated mice died.

Autopsies verified cause of death to be tetanus.

D.3 - THE EFFECT OF CROWDING ON DEER POPULATION

Studies done under controlled laboratory conditions are often met with scepticism because the organism may not be able to react as it would in the field. This objection is being overcome as more and more field experiments are conducted.

For example, the article below cites several incidents involving space and population. One has been selected for consideration here.

Natural History Dec. 1965 Ed. T. Hall
"Territorial Needs and Limits"

Sika deer are native to the Orient. In 1916, four or five of them were transported to James Island, a few miles off the coast of Maryland. James Island is less than 1/2 square mile in area (280 acres) and has no regular human population.

An acre is about 100' x 400'. 640 acres = 1 mi^2.

In 1950, Dr. John Christian started a study in depth of the deer population, including detailed examination of sample organs from the herd (heart, lungs, kidneys, spleen, thymus, and adrenal glands). Such things as sex, age, body fat, general condition, and other data were collected on each animal sampled.

By 1955 the herd size was estimated to be 300 (over 1 deer per acre). Dr. Christian's team was by this time involved in almost daily observation of the herd. No significant changes were observed until January - March of 1958, when over half of the herd died. By 1959, the herd was down to 80 deer, and it has been fairly stable at about that number since then.

In examining the dead deer, no signs of starvation were noted. They were, in fact, prime animals with some extra body fat. As a result of continued detailed study of the now smaller herd, some interesting relationships have been observed. Individual animals are larger: bucks are 34% heavier and does, 28% heavier.

The adrenal glands in these animals are 46% lighter than those in deer studied before 1958. In experimental animals, it has been found that continued stress results in abnormal growth of the adrenal glands.

The winter of 1958 was unusually cold in that area; this prevented the animals from swimming to shore - a standard practice. It is postulated that these "vacations" from the crowd at home may have provided badly needed breaks in the stress of individuals and that the inability to escape led to over-production of adrenalin and eventual death. The relationship between the population and "elbow room" seems to be as real as the one between food and the population, although the former is more elusive.

Results of work with mice, rabbits, muskrats, deer, and other mammals yield supporting evidence that internal mechanisms can regulate and limit population growth in response to increases in social pressure.

The movie entitled "The High Arctic Biome", to be used in the study of communities, introduces lemmings. Population pressure has been studied in these mammals also.

D.4 - MORE MOUSE FINDINGS

Under the stress of social pressure, mice have shown several responses which have a direct bearing on reproductive capacity (birth rate):

(1) Reproductive functions lessened in both sexes.

(2) Sexual maturation was delayed, or, at high population densities, totally inhibited.

(3) Weights of sex organs declined.

(4) The female's egg cycle was extended (more time between releases of eggs).

(5) Death of fetuses in the uterus increased.

(6) Inadequate lactation (milk secretion) in mice; nurslings were stunted.

(7) Crowding of female mice prior to pregnancy resulted in permanent behavioral disturbances. Future pregnancies were decreased.

(8) Occurrance of negative sex responses, believed to result from lack of hormones that stimulate the sex glands.

A big question is: can the data from mice, deer, and other animals be interpreted as applying to people? As the related arguments are resolved, the final statement may be that the population of man on the earth must stabilize. Even if all of the carrying capacity of the earth is somehow bent to mankind's needs, there is a maximum population which can be supported. Emigration will not solve the problem. The forces of stability which can be employed will be death rate (increase it) or birth rate (decrease it). In the past, famine, pestilence, and war have had the effect of modifying the growth curve of the human population by increasing the death rate. How will we choose to modify the curve in the future?

Chapter V: ECOLOGY

A. - INTRODUCTION

The following section is devoted to discussions and experiments dealing with ecology. Ecology is the study of the relationships between organisms and their environment, where the environment includes both the physical surroundings and other organisms. This branch of biology is becoming increasingly important to man because man himself is having a greater and greater influence upon his environment.

The primary objective will be to recognize that living organisms are constantly exchanging energy with their environments. The cells are not in states of equilibrium but are constantly synthesizing (putting together) and breaking down their molecular components. In order to gain more insight into the study of energy relations in a biological system we will study two different ecosystems: (1) a natural ecosystem on Isle Royale, and (2) a managed ecosystem at Odell Lake.

B. - ECOSYSTEMS

An ecosystem can be defined as the sum total of physical and biological factors operating in any one area. An ecosystem is a self-sufficient unit. Ecosystems may be very small, i.e. a fresh-water pond, or very large, i.e. the Sahara Desert or the Indian Ocean. In an ecosystem there is a cyclical exchange of materials and energy between living things and the environment. The minerals, the nitrogen and carbon compounds, and the water that living things require are continually recycled through the system. If the system is a balanced one, no materials are ever exhausted. The only requirement of an ecosystem is a constant input of energy. The ultimate energy source is, of course, sunlight captured by green plants in the process of photosynthesis. A generalized ecosystem is shown in Figure B.1 (next page).

B.1 - LIVING ORGANISMS

The living organisms in any ecosystem can be divided into three groups: producers, consumers, and decomposers. Producer organisms are those, such as green plants, that can manufacture food substances from simple components such as water and carbon dioxide. Plants are the ultimate producer organisms in any ecosystem. They are the only organisms that can use the energy of sunlight to power the food-producing process. Consumer organisms are those that feed

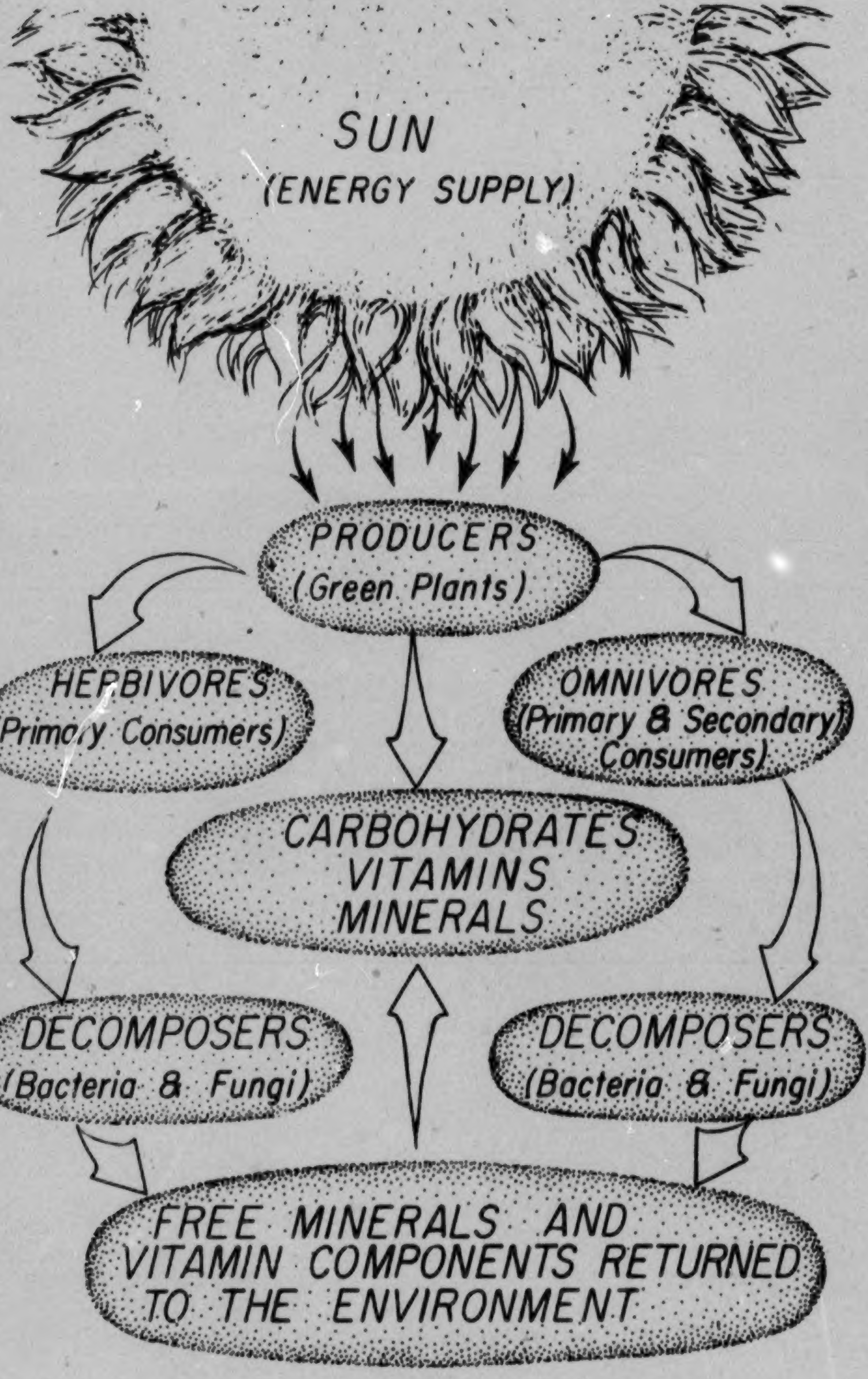

SUN
(ENERGY SUPPLY)
PRODUCERS
(Green Plants)
HERBIVORES
(Primary Consumers)
OMNIVORES
(Primary & Secondary Consumers)
CARBOHYDRATES
VITAMINS
MINERALS
DECOMPOSERS
(Bacteria & Fungi)
DECOMPOSERS
(Bacteria & Fungi)
FREE MINERALS AND
VITAMIN COMPONENTS RETURNED
TO THE ENVIRONMENT

Figure B.1

directly on other organisms. All animals fall into this category. Those animals that feed on plants are called herbivores. Herbivores may be considered first order consumers. In other words, they feed directly on producer organisms. Those animals that feed primarily on other animals are called carnivores. Carnivores serve as second order or third order consumers, depending on which organisms they feed on. Wheat growing in a field represents a producer. Cows, which feed on alfalfa, are first order consumers. Man, who feeds on the cow, is in turn a second order consumer. An organism feeding on man is a third order consumer, etc.

Decomposers are organisms such as bacteria and fungi that facilitate the breakdown of large molecules, releasing energy back into the environment, where it can be utilized by such organisms as producers in the photosynthetic response.

B.2 - FOOD WEBS AND ENERGY

The pathways by which energy is transferred from its source of capture in green plants through herbivores and carnivores are known as food webs. (Refer to diagram of food webs in the discussion on Odell Lake.) At every transfer in a food web, a certain portion of the energy appears as heat, which cannot be used as a source of metabolic energy and hence is "lost." Consequently, less and less energy flows through each successive stage until the final carnivores of the system may utilize only a small fraction of the total energy originally fixed in the system by photosynthesis.

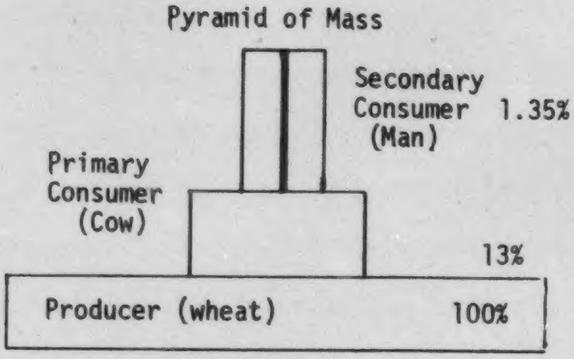
This flow of energy and of food material may be diagrammed in the form of a pyramid. There are several kinds of pyramids that can fit into an ecosystem, and there are two that we will consider in our discussion. These are the so-called pyramid of mass and the pyramid of energy. (See figures, p. 128) The pyramids consist of a number of levels that will be referred to as level 1, level 2, level 3, etc. At any level, part of the energy intake is used simply for the living needs or is lost as heat. For example, all the food consumed by an adult animal that is no longer growing, with the exception of energy devoted to reproduction, falls into this category. Only the energy used for the production of new protoplasm becomes available to the next level. In addition, many deaths will be due to causes other than predation, and this energy will flow to decomposers. As a result, the efficiency of energy transfer from one level to another is seldom larger than 10 percent.

An interesting question that occurs is "Why does each step along a food chain (which is the passage of materials from producer through primary, secondary, and tertiary consumers) extract only a fraction of the total potential energy of the previous step?" The decrease in available energy along the food chain is in agreement with the first and second laws of thermodynamics. The first law holds that energy cannot be created or destroyed but only changed in form. None of the energy in the universe is lost. The second law, however, states that the total amount of usable energy in any system tends to decrease with time. This is because no transformation of energy is 100% efficient. In a given transformation, some energy is always converted into heat.

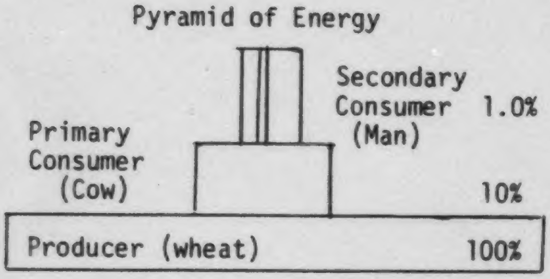
Recall Part Two, Chapter III, sec. E and Chap V, sec B.

One must thus view a pyramid (food chain) as a unit involving a series of energy conversions. With each transformation of energy from producer to consumer which forms the basis of energy chains in an ecosystem, there is a loss of usable energy along the food chain. When a cow eats wheat, for example, a great deal of the bulk consumed does not contribute to the nourishment of the cow. Much of it is indigestible and is returned to the environment in feces. In addition, the cow must move, reproduce, and carry on a great deal of other activity. This means that much of the carbohydrate contained in the grass must go to such functions. Only a small amount is actually formed into structural parts of the animal. This reduction in available energy is some indication why the competition for energy among many groups of organisms is often so severe. This is especially true if they all occupy roughly the same consumer level on the food chain.

In analyzing the food chain the student should recognize several important principles: (1) It will become obvious that in order to be complete and self-contained, any food chain must always have photosynthesis at the beginning and decay at the end. Energy must be constantly supplied from the outside in order to keep the food chain operating. (2) The shorter a food chain the more efficient it turns out to be. (3) The size of any population is ultimately determined by the number of steps in the food chain. With the decrease in useful energy at each step along the chain, there is very little energy available for populations of level 4 consumers. The size of a population of level 4 consumers is less than


Pyramid of Mass
Secondary Consumer (Man) 1.35%
Primary Consumer (Cow)
13%
Producer (wheat) 100%

a. Kilograms per hectare


Pyramid of Energy
Secondary Consumer (Man) 1.0%
Primary Consumer (Cow)
10%
Producer (wheat) 100%

b. Energy, g-cal./cm.^{2}

Fig. B.2 (a) Pyramid of mass and (b) pyramid of energy. The pyramid of mass shows that the total amount of material decreases at each level along a food chain. The pyramid of energy yields similar conclusions about the amount of usable energy at each step along a food chain. A great deal of both matter and energy is required from primary producers to sustain higher-level consumers in the food chain. (Data from G. G. Simpson, C. S. Pittendrigh, and L. H. Tiffany, Life: An Introduction to Biology. New York: Harcourt, Brace, & World, Inc., 1957, p. 622).

that of level 3 consumers, a population of level 3 consumers is smaller than one of level 2 consumers, and so on.

What follows are sections dealing with populations and communities. In reading through the discussions on populations and communities be aware of the principles discussed in the preceding paragraphs. Objectives to keep in mind are (1) the cycling and recycling of energy, (2) the decrease in mass as one goes up the levels, and (3) the loss of energy as one goes up the levels.

In a series of reports to the American public published through the Bureau of Documents in Washington, D.C. (Fauna of the National Parks of the United States, Fauna Series 7) there is one called The Wolves of Isle Royale by L. David Mech, PhD. The following is based on a popular version of the report.

C. - COMMUNITIES

All the populations living in a given area are called the community. Within a community we frequently study not only individual populations but also their interactions. Sometimes the interaction is rather indirect, as when a kind of beetle eats pine buds and kills the trees, which results in emigration of pine-seed-eating squirrels and eventually eliminates the marten (a squirrel-eating predator in the same family as the weasel). Likewise, the interaction is indirect when an elephant crosses a river and crushes hundreds of plants, leaving footprints in which little fish find shelter for their spawning activities. Or the interaction can be direct, as between a predator and its prey.

C.1. - ISLE ROYALE STUDY

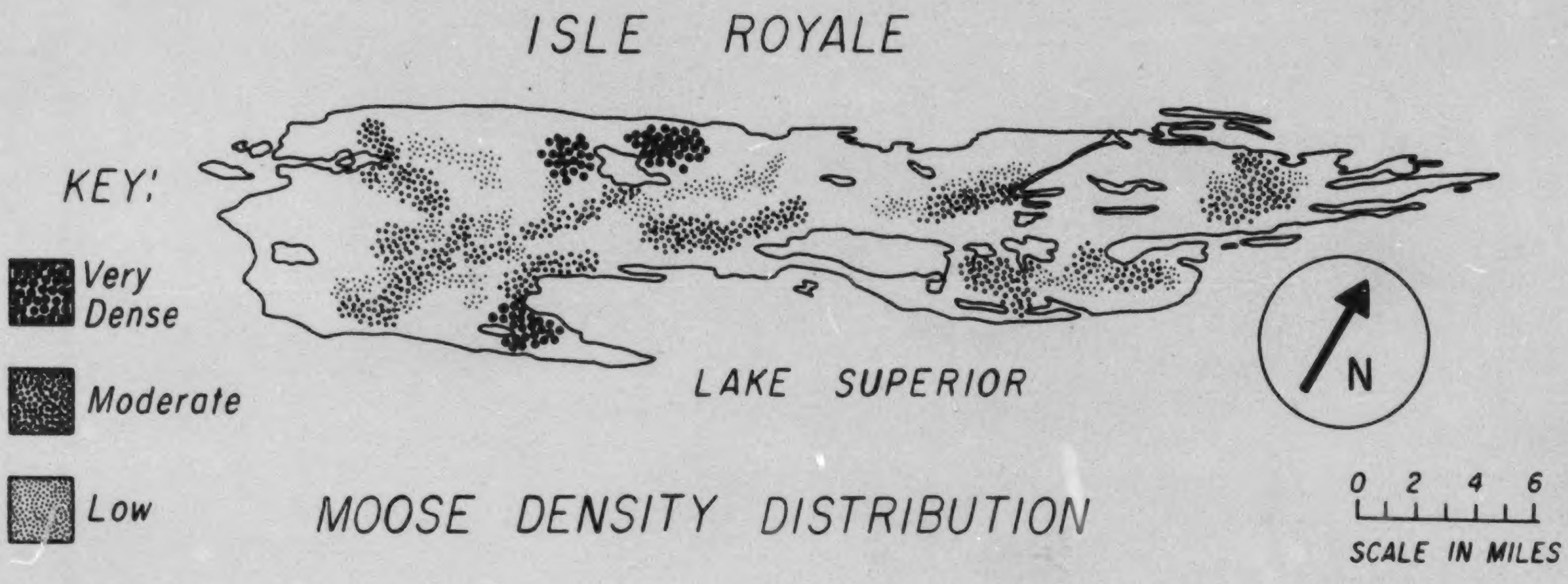
A good film to use with this section is:

Succession: From Sand Dune to Forest, 16 min, Encyclopedia Britannica, Lake Michigan setting.

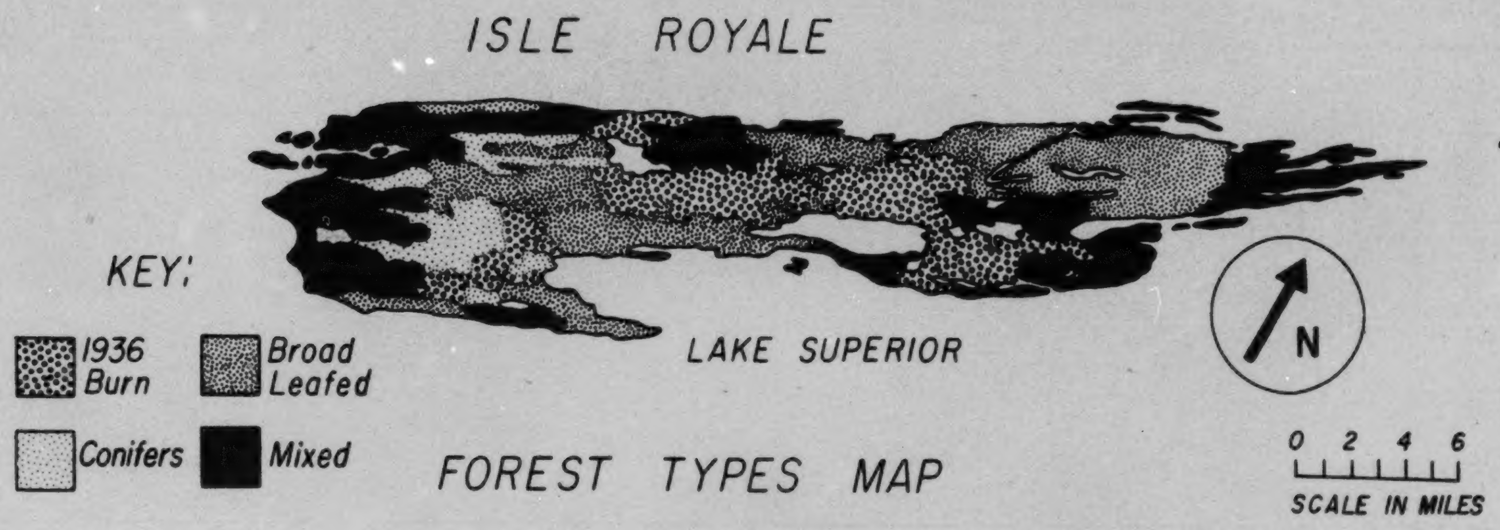
Situated some 15 miles off the Canadian coastline in Lake Superior is a natural laboratory which recently has been the scene of a ten-year investigation directed by Purdue University with the support of the National Science Foundation. Durward Allen and David Mech have written a non-technical account of the first few years of the study in National Geographic (February 1963). It is recommended that you look into the article for details and excellent photographic coverage of the synopsis presented here.

Isle Royale is about 45 miles long and ranges between 3 and 7 miles in width.

On the following two pages are maps of the island.


ISLE ROYALE
KEY:
Very Dense
Moderate
Low
LAKE SUPERIOR
N
0 2 4 6
SCALE IN MILES

MOOSE DENSITY DISTRIBUTION


ISLE ROYALE
KEY:
▨ 1936 Burn
▨ Broad Leafed
☐ Conifers
■ Mixed
LAKE SUPERIOR
N
0 2 4 6
SCALE IN MILES
FOREST TYPES MAP

It has many bays, spits, and lakes, making it a popular area for vacationers during the summer. The serious work of the study is carried on during about seven weeks each winter when the gray wolf, Canis lupus, hunts in packs. Much of the basic observation is done from airplanes, allowing the relatively small research staff to keep track of what is going on in their 210-square mile "test tube." Use of the airplane has permitted them to observe the pattern of behavior of the pack in 136 stalks and four kills of the American moose, Alces americana.

The investigators feel that their work has great biological significance because this island shelters nearly the last remaining population of the gray wolf in the United States. Prior to this study, the record of animal migrations to and from the island has been incomplete. It takes some hunting and more guessing to piece together a picture of the animal history of the island.

Ever since the island was formed there have probably been snowshoe hares, red squirrels, mink, weasels, and muskrats among the ordinary animal complement. It seems reasonable to predict that they will continue to be common residents in the foreseeable future. With the larger mammals the picture is not so consistent.

At the turn of the century caribou, lynx, and marten were reported on the island. None of these has been seen there since 1926. At that time foxes, coyctes, and beaver first appeared in the fur traders' records. Foxes and beaver are still around, but the last report of a coyote track was in 1957. It is deduced that the first moose crossed over to Isle Royale over the ice in the winter of 1912.

A biologist on foot made an estimate of the moose population in 1929. He reported between 1000 and 3000 moose. At 25 pounds of browse (shrubs, etc.) per day per adult moose, it is small wonder that the biologist suggested drastic control measures be taken to reduce the moose population. Nothing was done.

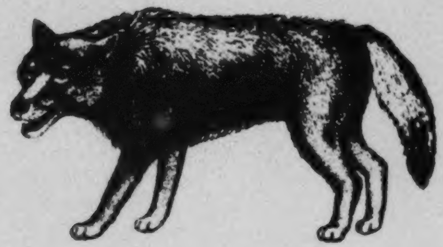
In 1936 a forest fire retarded the population explosion. In the reestablishment of the typical Lake Superior forest, a brushy scrub stage is common. This provides today even more food than the moose found on the island in 1912. One might, therefore, be surprised to find that in 1963 an air count of the midwinter moose population was 529 with an estimate of 600 as the probable total population of moose on the island. The moose population should produce at least 225 calves per year. Why hasn't the population exploded?

See Woolpy, J.H., "The Social Organization of the Wolf" in Natural History, May, 1968.

First observed in 1949, the wolf population in 1966 comprised twenty-one or twenty-two. In the four years of observation apparently only one wolf pup has been raised.

During the summer few people see the wolves. However, sightings of adult moose escaping from a wolf or two by wading into the lake suggest that moose calves (and beaver) are the chief summer diet for the wolves.

C.1.a - WOLF-MOOSE PREDATION



A wolf in the winter needs a lot of meat and bone. A cow moose that weighed about 800 pounds (100 pounds of waste) fed sixteen wolves for three days. They then ate sparingly for a few days until another kill was made. Male wolves weigh about 100 pounds and are larger than females.

A bull moose, if killed, would provide about twice as much food as a cow. There is a recorded observation of a healthy cow standing off at least fourteen wolves for the better part of a day. The pack then isolated a feeble cow and took the relatively easy meal in a few hours. It seems unlikely that very many prime bulls are ever attacked.

Sixty-eight kills have been examined. Often only blood stains and hair remained in a churned-up patch of snow. Sometimes, however, there was enough evidence to gauge the health of the moose.

Of the moose killed, the most common age was nine to ten years old. Calves less than one year old were the second most common group killed. No moose at all from one to five years of age were killed.

Forty-five per cent of the adult kills examined were in poor health as well as being old. The kills included eleven which had lumpy jaw (a form of cancer) and fourteen which had little or no fat in the bone marrow (anemic). All had numerous tapeworm cysts in their lungs.

These figures tell us about the winter, but in the summer the community does not estivate (shut down for the summer). Since the calculations are based on winter observations, conjectures about the summertime relationships are based on a number of assumptions such as:

1. Moose calves as well as adults are available for the wolves to catch.

2. Moose calves require less energy to catch but provide less poundage of meat per kill than adults. (A full-grown moose weighs about 800 lbs.; calves may weigh as much as 200 lbs.)

3. Wolves need as much food in the summer as in the winter.

4. Wolves depend on moose to provide the same proportion of their diet in the summer as in the winter.

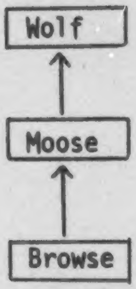
5. The moose produce about 225 new members per year. Since the moose population is nearly stable about 225 moose must die per year.

The estimated winter kill of about 50 moose was based on adults, which are bigger than calves. If these assumptions are true, the wolves are not getting enough food from the moose herd to survive.

Therefore, they must eat other things too. Careful inspection of "scats" (feces) and chance observations indicate that beaver are the other prime source of wolf food (20%) but that snowshoe hares and foxes are also eaten. The picture of the food relationships becomes more complex.

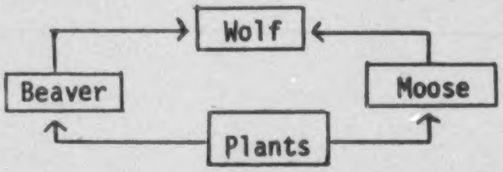
C.1.b - ENERGY TRANSFER ON ISLE ROYALE

So far we have looked at a food-chain: browse - moose - wolf. What about all the other kinds of organisms on the island? Who eats whom? The large mammal picture is fairly well established.

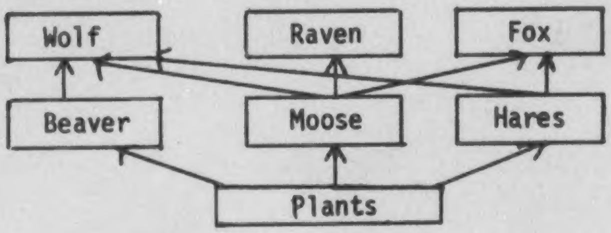

Wolf
Moose
Browse

The arrows on this kind of food chain indicate the energy flow. Sometimes arrows pointed the other way are used to indicate consumption of organisms on the next lower level.

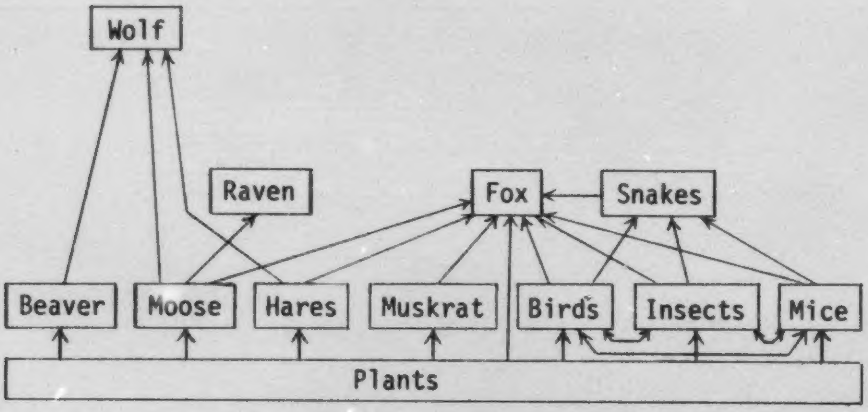
The beaver complicate the simple chain.


Wolf
Beaver
Moose
Plants

But wolves also eat snowshoe hares, although most of the hares killed are eaten by foxes. In addition, foxes are known to eat a portion of most moose killed by the wolves. Furthermore, ravens obtain most of their winter meat from wolf-killed moose.


Wolf
Raven
Fox
Beaver
Moose
Hares
Plants

Foxes get about half of their food by killing hares; the other half is mostly made up of snakes, birds, muskrats, moose, plants, and insects.



The pattern emerging is called a food web. Food webs are used to depict the pattern of energy transfer observed within a specific community.

Note that the energy which is transferred or moved through the community does not originate within the community but is captured from the sun by green plants. Each community tends to reach a steady state, so that a particular community of living things develops in a location which has particular environmental factors.

It may appear that the wolves occupy a favored position in which they alone are not eaten. They do however share with all the rest of the community the problem of parasites. Small organisms (fleas, ticks, tapeworms, etc.) use even the top consumer in the community as a source of food. Other organisms called degraders and decomposers (termites, worms, fungi, bacteria) further equalize the situation by reducing wolves, moose, trees - all the members of the community - to components of the soil and atmosphere.

This island now shows the earmarks of a balanced community in terms of large mammals. All natural communities tend to reach a self-perpetuating state or to become climax communities eventually. For example, in the moose herd twinning occurs in 38% of the cows with calves. Twenty-eight % is considered high. Twinning is an indication of a healthy herd where cows are in prime condition.

Note that this is the first use of the term "climax community."

An estimate of the 1960 carrying capacity of Isle Royale was a density of 5 to 10 moose per square mile or one or two thousand moose.

Exercises for Home, Desk, and Lab (HDL):

(1) How much moose meat does a wolf need each day to survive in the winter? (Try to work in terms of maximum consumption and recognize that your answers must be estimates.)

(1) From the article: 800lb - 100 lb = 700 lb; 16 wolves x 3 days = 48 wolf-days; max intake = 14lb/day/wolf. (Since they ate sparingly after the kill, this is probably not an average daily diet.)

(2) How much meat does the wolf-pack need daily to survive in the winter?

(2) 22 wolves x 14 lb/day/wolf = 308 lb/day.

(3) 100 days x 308 lb/day = 30,800 lb/winter
@ 700 lb/moose = about 44 moose/winter

(4) 9,125 pounds (25 lb/day)

(5) 9,125 x 600 = 5,475,000 lbs.
(5.5×10^6 lbs.)

(6) 9,125 x 1,000 = 9,125,000 lbs. (min.)
9,125 x 3,000 = 27,375,000 lbs. (max.)
(27×10^6 lb.)

(7) Using figures from this book, the results should be:
5.5×10^6 lb. browse eaten
4.8×10^5 lb. moose
1.1×10^5 lb. moose eaten
Mech, using more detailed estimates, comes up with:
89,425 lb. moose consumed
1,156,400 lb. moose

5,823,300 lb. browse consumed

Fauna Series #7 - Wolves of Isle Royale, Bureau of Documents, Washington, D.C., Cat. No. I 29.13:7 Cost - $1.00

Appropriate films are:

"The Community," EBF
"Tropical Rain Forest," EBF
"The Grasslands," EBF
"Life in a Pond," Coronet film, 10 min.
"The Sea," EBF
"The Cave Community," EBF
"The Desert," EBF
"High Arctic Biome," EBF
"World in a Marsh," McGraw Hill, 22 min., color (Natl Film Bd. of Canada)

(3) How many moose did the wolves eat during the one hundred days of winter? (Assume 800 lbs. is the largest size moose killed.)

(4) How many pounds of plants does a moose eat in a year?

(5) How many pounds of plants does the moose population eat in a year?

(6) How many pounds of plants would the moose population of 1929 have consumed?

(7) Compare the number of pounds of browse consumed by the moose, the number of pounds of moose, and the number of pounds of moose consumed by the wolves. (Assume the 100 - day winter rate continues through the year.)

(8) Graph the following moose population data, indicating on your graph any periods in which the carrying capacity of the island was exceeded.

1915 - 200
1920 - 300
1925 - 2,000
1930 - 3,000
1936 - 400
1945 - 500
1948 - 800
1950 - 500
1957 - 300

These figures are samples and were obtained in a variety of ways, so they are not expected to be exact. Recall events in the narrative which would have resulted in marked population changes.

The graph should show great fluctuations of population and constant carrying capacity.

C.2 - INDIVIDUAL STUDY

In order that you may become familiar with the problems of studying a community, you will be asked to plan and carry out a study of your choice. The laboratory aspect of a community study is complex and not readily adaptable to class periods; therefore, finding a suitable time and place may be a challenge.

You will be expected to turn in a written report of your observations and interpretations. Specific questions asked at the start will help focus observations and should be answered - if possible - in your report. Be sure to describe your equipment and the procedures you followed. Pictures may be a helpful addition to written material. Patterns of movement may be mapped for some organisms.

Useful rules include:

1. Size of the study plot should be between 10 cm^3 and 100 cm^3.

2. Observations should be made at different times of the day and for varying

These projects will extend over a considerable period of time. Many of these studies should be made over a period of weeks. In individual cases the subject of study may appropriately involve Parts One, Two, Three, or earlier chapters of Part Four rather than a community study.

Good help is available from: Savory, T.H., "Hidden Lives," Scientific American, July, 1968;
BSCS lab blocks:
Life in the Soil;
Physiological Adaptation;
BSCS Green version lab manual.

Another type of activity involves using a series of films on biomes with individuals or groups assigned to report on a community and its physical environment.

lengths of time.

3. Avoid disrupting your study plot. Perhaps a comparable area could be utilized for census taking or other disruptive activities.

Possible questions to be answered by observation and interpretation are:

1. Does light fall on the plot evenly?
2. Does the light pattern affect the organism?
3. Do other physical factors affect the organism?
4. Is the food web of the community self contained?
5. What enters from outside the community?
6. What lives in and on the study plot?

Below is a list of suggested topics. These are not considered complete but rather are limited so that they are manageable by the student yet are real parts of a larger study.

1. Mossy rock.
2. Small pond.
3. Flower or leaf cluster on the end of a branch.
4. Litter around the base of a shrub.
5. An anthill.
6. A bird's nest.
7. A decaying log.

8. Build an aquatic community in a gallon jug.

9. Detailed study of one kind of organism.

10. A census and key of selected organisms.

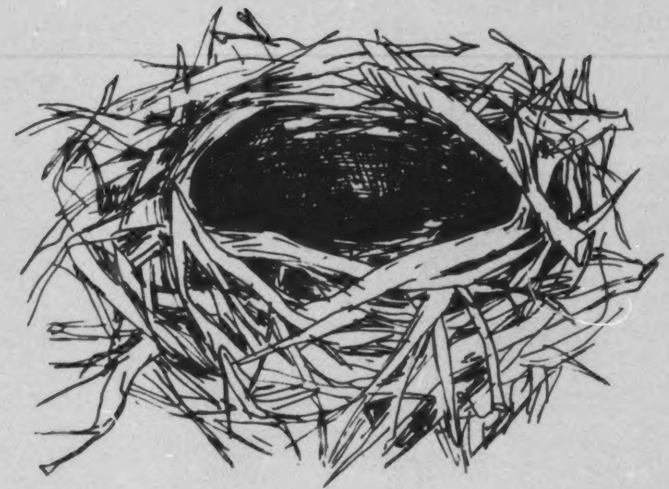
11. Willamette River pollution.

12. Night vs. day on the study plot.

13. Life cycle of an organism.

14. Responses of a particular environment by a particular organism.

15. Some other topic selected jointly by student and teacher.



Materials and Equipment:

(each student)
- *microscope*
- *millimeter ruler*
- *medicine dropper*
- *two blank slides, coverslips*
- *pH paper*

(class stock)
- *one or more aquaria containing water sources from different environments.*

The aim of this exercise is to gain insight into the characteristics of certain types of ecosystems. Have the students recall the definition of an ecosystem from an earlier section.

For aquaria either the commercial kinds or gallon jars can be used.

Suggest that water samples be collected from a lake, pond and/or river one week prior to exercise.

C.3 - Experiment: ECOSYSTEMS

C.3.a - INTRODUCTION

In this laboratory study of ecosystems you will (a) examine samples of certain water ecosystems, and (b) assess the relationships between the environments and the organisms. More specifically you will try to determine how a given environment makes possible and influences the existence of certain organisms and how the organisms in turn influence the environment. In the course of this exercise you will observe organisms whose names you do not know and which will be unfamiliar in other respects as well. It is suggested that you design some method so that each species of organisms observed can be recognized, i.e. a, b, or x, etc., or some "name" that will serve to designate the organism in the mind of each member of the class. It is important, however, that some consistent system designation be shared among the students within the class. For this purpose a sketch of the organism might be helpful.

Your primary goal will be to try to understand how a selected organism is able to live in the particular environment in which you find it. "Living" means that certain vital processes must be carried out; living in a particular environment means that this environment will impose certain limitations and conditions which may effect the method, or the ease, in which given vital processes can be carried out. Your procedure, therefore, should be as follows:

1. To study the nature of a given external environment and to fix in your mind the physical, chemical, and biological factors that distinguish this environment from others.
Examples: temperature, pH, clear or turbid water, etc.

2. To fix in your mind the vital processes any organism must perform if it is to remain "living," i.e. producer, consumer, decomposer.

3. Correlate item 1 with 2; determine the position and role of each organism in a characteristic food chain and/or food web.

4. Then examine briefly the appearance, external structure, behavior, color and other recognizable characteristics of given organisms, and judge how many of those species you believe to be the solution to the particular problem created by the environment.

C. 3. b - DIRECTIONS

Using an eyedropper, take samples from various depths within each aquarium and make covered wet mounts of drops of these samples.

Study each thoroughly and without hurrying as outlined below.

Conduct microscopic examinations of each sample, making sketches and identifying all organisms seen in the field. Count the number of organisms in the field; record the types of objects seen, in terms of living material and non-living material in the field; note specifically the motility or non-motility of living organisms in the field.

If fast-moving organisms are present, prepare a clean, blank slide and paint a shallow ring of methyl cellulose on it, about 1/4" to 1/2" in diameter. Put a fresh drop of the sample you are studying into this ring and cover with a coverslip. After a few minutes, some of the methyl cellulose will have diffused centrally into the water drop, which will slow down or stop any fast-moving organisms.

Also note the shape of the organisms, indicating the many different shapes that are distinguishable among the organisms, both motile and non-motile. It might be to your advantage to sketch as many various shapes as you can and attempt to correlate shape, motility, and speed of locomotion. Note also the size of the organisms, observing how many different sized classes of living organisms are found in the ecosystem. The color of organisms might be a useful item to indicate. Note specifically if organisms of one color predominate over those of other colors. The external structure of the organism might be important; i.e. does one have a hard exoskeleton, such as that of the crawfish, or is the exoskeleton non-existent, as in a protozoan. Record also the different number of species found and attempt to estimate the number of different species and their relative abundance. Describe any other noteworthy features of the visible organisms and of the preparation as a whole. Also, measure the pH of the sample by using the universal pH testing paper provided, checking the result against the color charts supplied with the paper.

After having examined the different stock samples independently, make itemized note by note comparisons as above. You should have compiled a data table and should now use this data to interpret the ecosystem along the lines suggested in the introduction.

The techniques and facility of working with an ecosystem as gained in this exercise will be useful in the following section dealing with pollution. It is therefore suggested that the student keep reference charts and lists for later utilization.

C.3.c - COUNTING THE POPULATION (work in pairs)

Place 2 drops of water (about 0.1 ml) on a clean slide. Place a clean coverslip over the culture on the slide. Position the slide on your microscope stage and focus under low power, then switch to high power.

Count the number of individual organisms in 5 different high-power fields (see sketch below). Record the 5 counts below on line A.

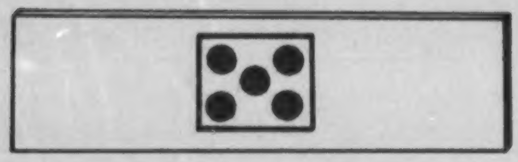


Figure C.1

If the fields are too crowded for easy counting, you must make a dilution of the sample. To do so, place 20 drops of the sample into 9 ml of water and mix the contents thoroughly. Then transfer 2 drops from the dilution tube to a slide and proceed to count as above.

The partner on this team should also make 5 counts from the sample and record on line B below. Compare your average count with your partner's. If the averages differ by more than 10 organisms, prepare new slides and repeat the count.

	Fields					Total	Average	Average x dilution figure
	1	2	3	4	5			
A								
B								

DATA SHEET

	aquarium 1	aquarium 2	aquarium 3	aquarium 4
Number of objects high-power (average)				
Types of non-living materials				
Number of living objects, high power				
Number of motile & nonmotile forms				
Number of different motility types				
Number of shapes among organisms				
Number of size classes among organisms				
Number of colors among organisms				
Notes on external structure				
Number of species				
pH				
Clear or turbid				
Other features				

C.4 - ODELL LAKE

Studies of natural communities enable man to alter and control environmental factors, physical or biological, toward ends which he deems desirable. The Oregon Game Commission has permitted us to look at some of their data related to Odell Lake in order that we might examine this example of man's management of a community. One problem is to provide recreation for an exploding number of anglers, so they attempt to shift communities in lakes to favor the production of Rainbow Trout and other popular species.

The lake community is no more complex than the Isle Royale community, but the populations are less familiar. The details of density and distribution throughout the lake and the exact food web involved are necessary background to set the stage for solving the practical management problem. Sometimes food webs established at one lake bear little resemblance to those found elsewhere, so it is a practice to establish this information for each situation. The information for this analysis comes in bits and pieces, and sometimes economic considerations have a greater effect than they should on reliability.

The points will be based primarily on information about Odell Lake in Oregon; rarely the information will be from another Oregon lake or taken from common knowledge about some species, which may have been confirmed but not reported by the team at Odell Lake.

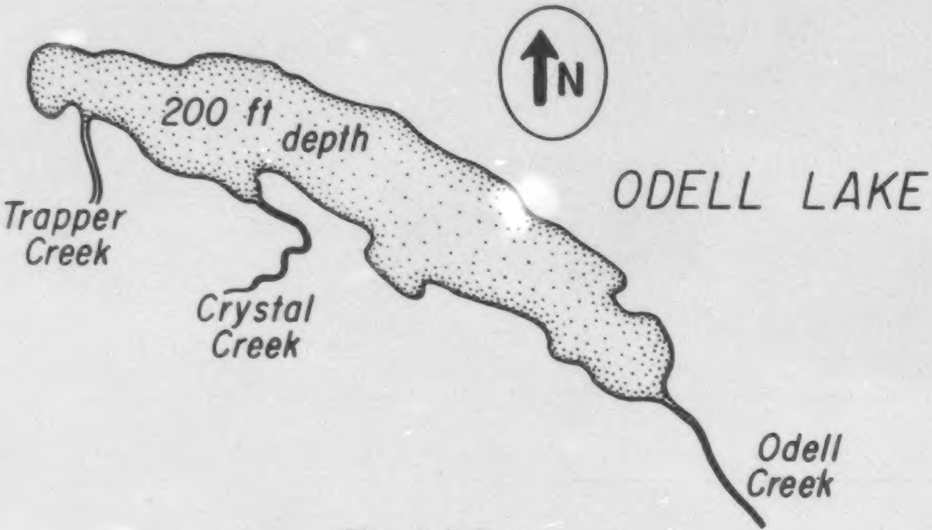

200 ft depth
N
ODELL LAKE
Trapper Creek
Crystal Creek
Odell Creek

Figure C.2

5 miles by 1.5 miles

Altitude 4,792 feet

Surface area 7,500 Acres
(including 500 acres of shoals)

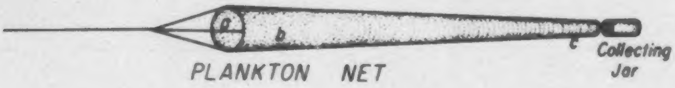
Some data from gillnetting (6ft. x 200 ft. net):

	1940	1941	1946
Dolly Varden (Ave. 4 lb.)	.22 lb./hr.	.43 lb./hr.	---------
Kokanee (Ave. 1.5 lb.)	----------	----------	.30 lb./hr.
Roach (or Whitefish)	12.2 fish/hr.	----------	33 fish/hr.

1949 creel census in order of occurrence: Kokanee, Dolly Varden, Rainbow trout.

C.4.a. - ODELL LAKE PLANKTON

A series of vertical plankton hauls were made in Odell Lake from April through June. The samples of plankton taken demonstrate some traits of communities. The reliability of the conclusions may be questioned because the sample is very small - the lake is 5 miles by 1.5 miles and about 250 feet deep in spots - and each haul represents a column of water less than one meter in diameter and about 16 meters deep.



PLANKTON NET

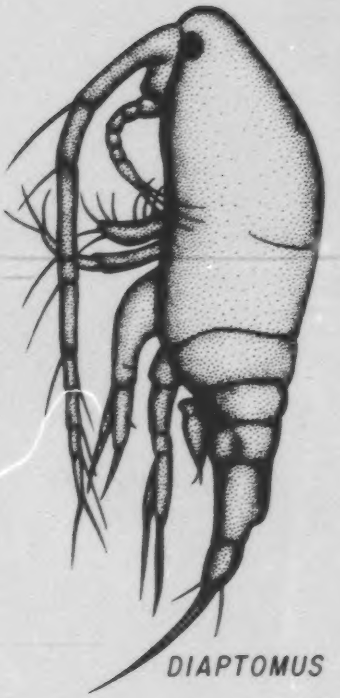
Figure C.3

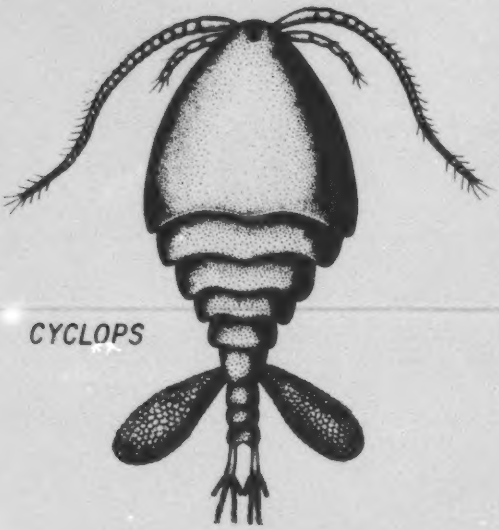
Everything which enters at "a" passes down the funnel, "b".

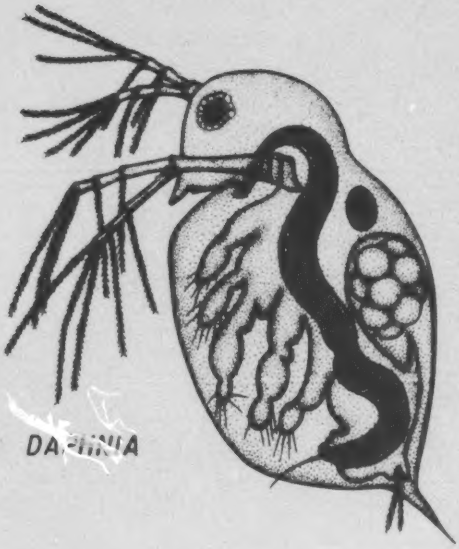
The mesh at "c" has holes of specified diameter to let out water and retain plant or animal plankton.

A vertical haul is made by dropping the weighted net over the side (rolled up). When enough line is paid out, a second line releases the weight and unrolls the net. The haul is then made by pulling the net up with vigor.

Odell Lake plankton usually include the copepods Diaptomus, Epischura, and Cyclops, and the Cladoceran, Daphnia. On the next page you will find three of these pictured. Epischura, which is not shown, is much like Diaptomas, except that it is red in color.







All these small animals (about 1 mm. in length) are relatives of the sow bugs used earlier. However it is easier to see the relationship of these animals to shrimp than to sow bugs.

Plankton components of vertical hauls during a 2-month period are shown on the following page.

Figure C.4

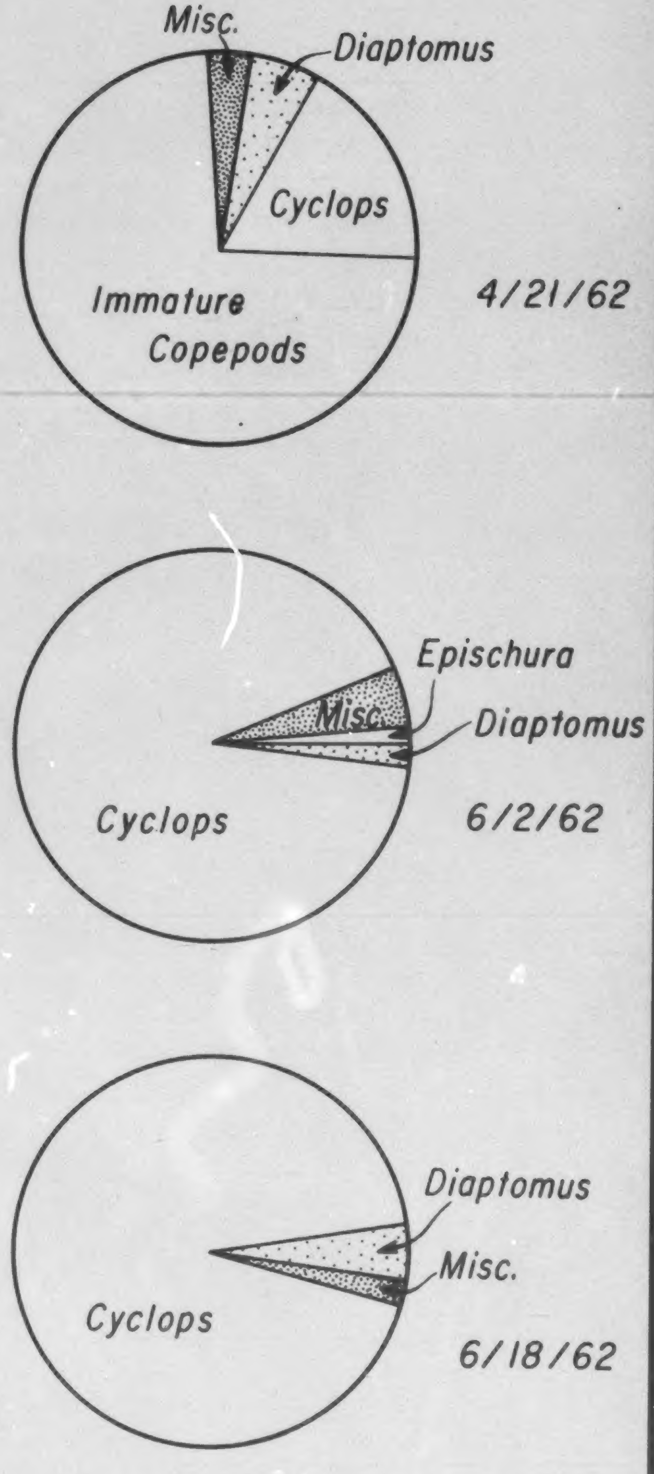
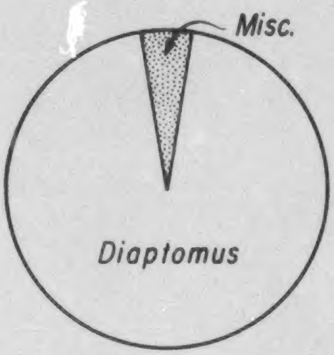

Misc.
Diaptomus
Cyclops
Immature Copepods
4/21/62
Epischura
Misc.
Diaptomus
Cyclops
6/2/62
Diaptomus
Misc.
Cyclops
6/18/62

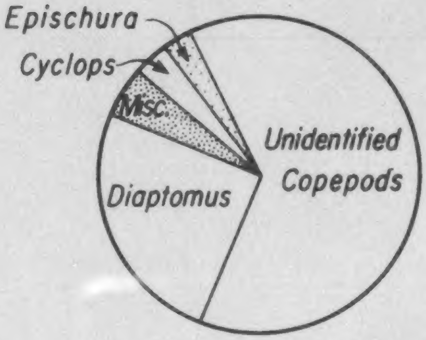
Figure C.5

Over a period of time, the community shows a fairly stable picture with Cyclops as the dominant type and the other types in very limited numbers.

On 6/2 and 6/18 the stomach contents of 3 or 4 Kokanee were examined providing data for the following graphs.



CONTENTS OF THREE STOMACHS 6/2/62



CONTENTS OF FOUR STOMACHS 6/18/62

Figure C.6

1. Kokanee eat plankton.
2. They eat more Diaptomus than anything else.

Watch out for inferences such as: they seek out Diaptomus in preference to other food.

What can we learn from the data in Figure C.6?

The previous graphs were about Kokanee feeding habits. The graphs below are based on plankton hauls from selected depths - 6/18/62.

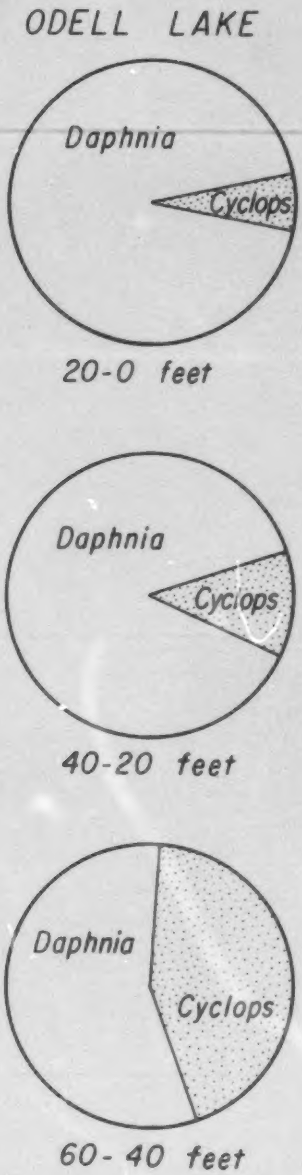


Figure C.7

The material on selected-depth vertical hauls indicates another community trait. As conditions within the geographic bounds of a community vary, the relative numbers of different species within the community vary: Cyclops increases with depth, Daphnia decreases.

C.4.b. - ODELL LAKE GAME FISH

Can we infer further information about Kokanee?

A simple observation if pursued often arrives at a point of great complexity, and trite answers if not wrong are often at least only partially correct. Also note answering questions may generate more problems than have been solved in finding the answers.

Looking back to the vertical plankton hauls (0-50 ft.), Diaptomus is relatively rare (5%) yet in the stomachs of the Kokanee they were very common (95%). The great disparity in frequency raises several questions:

> *Does Kokanee hunt for Diaptomus? How can it spot them as different? Is it coincidence?*

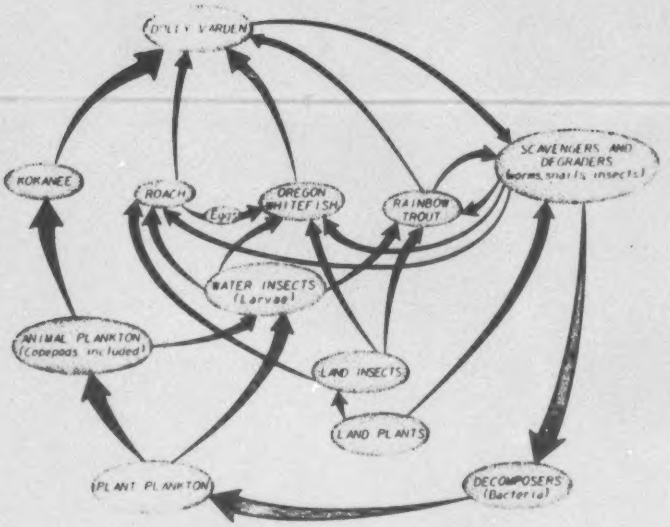
There are several possible reasons for the high rate of Diaptomus in the food of the sample fish. Foremost would be the simple fact of proximity within the lake. However, they may not have been there for the same reason(s).

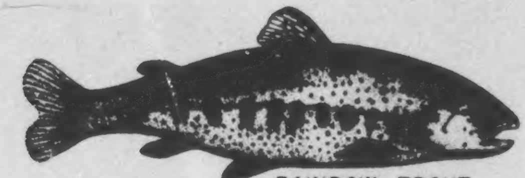
As water gets deeper it usually gets colder, denser, richer in oxygen, poorer in minerals, and poorer in light. Diaptomus may seek a certain temperature, sink or float into the right density, or may seek a certain level of chemical balance or light intensity. Or the things Diaptomus eats may do the above, leading it to seek them in a particular layer of water.

The Kokanee may be responding to any of the physical factors mentioned or to the biological factors. It cannot be established which of the factors bring the two organisms together. Nevertheless, the coincidence of their presence tells us that Kokanee seem to prefer one layer of the water in Odell Lake.

You have some indication of how the populations in the community were sampled. Using such information the food web below has been constructed.

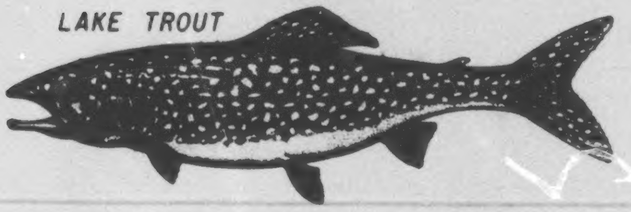
ODELL LAKE FOOD WEB

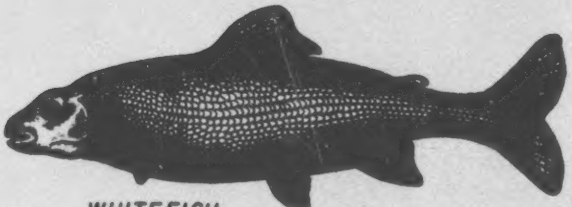

DOLLY VARDEN
KOKANEE
ROACH
Eggs
OREGON WHITEFISH
RAINBOW TROUT
SCAVENGERS AND DEGRADERS (worms, snails, insects)
WATER INSECTS (Larvae)
ANIMAL PLANKTON (Copepods included)
LAND INSECTS
LAND PLANTS
PLANT PLANKTON
DECOMPOSERS (Bacteria)



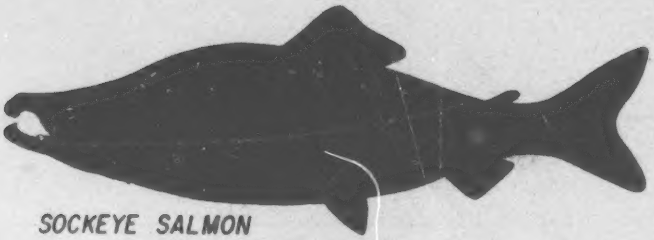
RAINBOW TROUT

LAKE TROUT



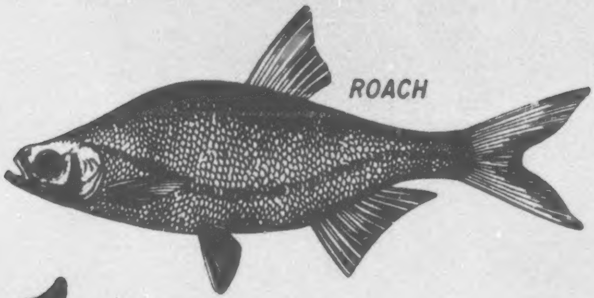


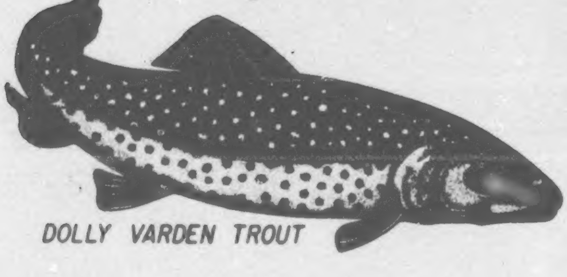
WHITEFISH



SOCKEYE SALMON

ROACH





DOLLY VARDEN TROUT

The biologist, once aware of the natural interrelationships, may decide it is necessary to change the pattern. The problem is to determine which change(s) to make.

This will depend on the end in mind. Let us suppose that it is desirable to increase the yield of Rainbow Trout. How would you proceed? Since there are no hard and fast rules to direct this, you may arrive at different answers, all of which can be right.

Whitefish compete with Rainbow Trout for worms, insects, etc.

Larger Rainbow Trout would not be preyed upon by the Dolly Varden as much as fingerlings.

The biologist suggested that the Whitefish be controlled (trapped and converted into fish food) and that the lake be stocked with legal-sized Rainbow Trout (at least 6 inches) as opposed to fingerlings.

Fishermen usually are not partial to the Dolly Varden and have a tendency to destroy them. At Odell Lake this has been the history of Dolly Varden, and their population has been in a steady decline for some 20 years. This has had a positive effect on the Kokanee catch from the lake, but it has had other effects as well. The birth rate of both Roach and Whitefish is greater than that of the Rainbow Trout or the Kokanee. Which of the two game fish would be affected most by an increase in the Roach and Whitefish populations?

In other lakes it has been shown that Roach can replace most other species in 3 to 6 years if no control measures are used. This has not occurred in Odell Lake even though only limited control has been exercised by man. Observations of Whitefish schools following spawning schools of Roach indicate that the former are exercising biological control of the Roach population by eating their eggs.

In one season at Odell Lake, 6 tons of Whitefish were removed from traps on their spawning grounds. It was not known at the time whether or not to expect a Roach population explosion as a result of reduced egg predation.

Actually removal of the mass of Whitefish had several effects: the way was cleared for a large number of other insect-eating fish -- more appreciated by anglers; plankton and other food was made more readily available to other fish without competition; and organisms which had preyed on Whitefish turned to Roach as a source of food.

The Lake Trout, a fish eater, has been given great attention and help in Odell Lake although Kokanee are still the most intensely studied group. Game Commission biologists are currently studying the possibility of introducing other species as well. Does it appear that Odell Lake can support several large species of game fish?

Yes. For example, Rainbow Trout and Kokanee.

The study of populations and communities is part of a larger branch of biology known as ecology, which you will recall is the study of the interrelationships between organisms and their environment. As the dominant organism on the earth today, man frequently plays a large role in changing his environment. (When he cannot do this he sometimes builds himself an artificial environment.) The rapid expansion of the human population is creating severe problems of pollution and waste disposal, and it is creating a profound effect on the survival of other living things. Just as man has intervened in the balance of nature in Odell Lake, so too he must learn to recognize and adapt to the intricate balance throughout the whole living world.

TEACHER'S GUIDE

ENVIRONMENTAL BALANCE

AN INTEGRATED SCIENCE SEQUENCE

1970 EDITION

DIRECTOR:
Dr. Karl Dittmer
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Portland, Oregon

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A Note to Teachers

"Environmental Balance " is particularly well suited for its location in the sequence. It offers the teacher maximum flexibility in its implementation. If the Year I instructor is on schedule, approximately one month will be available for Part IV at the conclusion of the first year. The recommended sequence is as follows:

8 Days: *Introduction: Chapters 1-4 of the text, including a common laboratory experience and any additional speakers, visual aids, etc. that the teacher wishes to utilize for a multimedia introduction. HDL's may be used to supplement text materials.*

10 Days: *Individual and/or small group activities of the student's choice. This may include extension of the common laboratory experiment, other laboratory work, research within the community, or any number of other activities. The HDL's provide many ideas for the individual or small group projects.*

2 Days: *Summarizing and reporting of the results of the individual or small group investigations, plus Chapter 5 of the text.*

If time is short, the individual- or small-group-activities phase may be easily reduced. If time is extremely short, the teacher may wish to build a short unit (1-1½ weeks) around the text itself, using the HDL's as a springboard for class discussion in various areas and utilizing visual aids, speakers, panels, and other media. If a teacher wishes, either because of his special interest or student interest in his school, he may emphasize material on some topic other than water and air pollution during the classroom phase. This could be accomplished by choosing HDL's and visual aids to serve as the basis for the classroom discussion and activity. Four or five HDL's have been included that introduce other topics, such as solid waste disposal, populations problems, etc. A chart immediately preceding the HDL's indicates the areas to which they apply.

If additional time is available, the teacher may extend the introductory phase by bringing in more visual aids, speakers, or laboratory activities or by extending the individual or small group activity period.

No evaluative materials have been developed by the project, since evaluation will be determined by the manner in which the teacher implements the unit.

Teachers will find it beneficial to have available many laboratory manuals and other reference materials for student use during the project and activity phase of the unit. In addition, it has been found helpful to establish a cumulative room library of such items as pamphlets, reprints, newspaper articles, magazine articles and other related materials. The teacher should make every effort to be aware of the local, state, regional and federal agencies that can provide information or services for students or teachers, and in addition identify those clubs, organizations, colleges and universities, or other sources that may provide speakers, films, literature or other types of help. A wide range of motion pictures are available, but the demand is great and teachers will have to order well in advance (several months to a year) if they wish to obtain them when desired. A partial listing of some sources of various media and/or services follows. This listing should be used *as information and not considered to be a recommendation. No endorsement is intended by this list, and any omissions are inadvertent.*

MOTION PICTURE FILM SOURCES

National Medical Audio-Visual Center
Chamblee, Georgia 30005

Free loan on all films from this source.

Audio Visual Instruction
Division of Continuing Education
Gill Coliseum 133
Corvallis, Oregon 97331

Rental fee charged for many films from this source.

Forest Service, USDA
319 S.W. Pine St.
P.O. Box 3623
Portland, Oregon 97208

Oregon State Board of Health
State Office Building
1400 S.W. 5th
Portland, Oregon 97201

Short-term free-loan policy in effect at this source for the State of Oregon.

Multnomah County Library
801 S.W. 10th Ave.
Portland, Oregon

For residents of Multnomah County.

Your school district and/or county or regional film library.

All of the above have a listing or catalog of films available.

AGENCIES FOR INFORMATION AND/OR SPEAKERS

Department of Health, Education, and Welfare
Environmental Control Administration
12720 Twinbrook Parkway
Rockville, Maryland 20852

This is an excellent source for a variety of materials dealing with solid wastes. In addition, this Administration has bureaus working in the areas of water hygiene and radiological health.

National Air Pollution Control Administration
801 North Randolph St.
Arlington, Virginia 22203

Department of Health, Education, and Welfare
Public Health Service
Bureau of Occupational Safety and Health
1014 Broadway
Cincinnati, Ohio 45202

Excellent source of information on noise as an environmental health problem.

Division of Technical Information
U. S. Atomic Energy Commission
Washington, D.C. 20545

U. S. Department of the Interior
Federal Water Pollution Control Administration
Washington, D.C. 20203

U. S. Department of Health, Education, and Welfare
Public Health Service
National Center for Air Pollution Control
Washington, D.C. 20201

United States Atomic Energy Commission
P.O. Box 62
Oak Ridge, Tennessee 37830

Bureau of Solid Waste Management
Office of Information
5555 Ridge Avenue
Cincinnati, Ohio 45213

Office of Information
U. S. Department of Agriculture
Washington, D.C. 20250

Pacific Northwest River Basins Commission
P.O. Box 908
Vancouver, Washington 98660

Water Resources Research Institute
Oregon State University
Corvallis, Oregon 97331

Federal Water Pollution Control Administration
Northwest Region
Pacific Northwest Water Laboratory
200 S.W. 35th Street
Corvallis, Oregon 97330

Oregon State Water Resources Board
500 Public Service Building
Salem, Oregon 97310

Federal Water Pollution Control Administration, Northwest Region
U. S. Department of the Interior
501 Pittock Block
Portland, Oregon 97205

The next 7 agencies are located in the State Office Building, 1400 S. W. Fifth Avenue, Portland, Oregon 97201.

Oregon State Department of Environmental Quality

Air Quality Control
Water Pollution Control

Fish Commission of Oregon

Oregon State Geology & Mineral Industries

Oregon State Board of Health

Oregon State Justice Department (Attorney General)

Oregon State Pacific Marine Fisheries

Oregon State Board of Sanitation

Oregon State Game Commission
1634 S.W. Alder
Portland, Oregon 97205

Oregon State Population Research & Census
614 S.W. Montgomery
Portland, Oregon 97205

Oregon State Highway Department
5821 N.E. Glisan
Portland, Oregon 97213

Water Pollution Control Commission
P.O. Box 829
Olympia, Washington 98501

Department of Water Resources
335 General Administration Building
Olympia, Washington 98104

PRIVATE ORGANIZATIONS THAT MAY BE OF HELP

Those that are listed are primarily national in scope. Many will have local, state, or regional chapters which could be contacted directly. In addition, there may be a wide range of local, state, or regional organizations that could aid you.

Air Pollution Control Association
4400 Fifth Ave.
Pittsburgh, Pa. 15213

American Association for Conservation Information
1416 Ninth St.
Sacramento, Calif. 95814

American Cancer Society
219 E. 42nd St.
New York, N.Y. 10017

American Fisheries Society
1040 Washington Bldg.
15th & N.Y. Ave., N.W.
Washington, D.C. 20005

American Forestry Association
919 17th St., N.W.
Washington, D.C. 20006

American Littoral Society
Sandy Hook
Highlands, New Jersey 07732

American Society of Planning Officials
1313 E. 60th St.
Chicago, Ill. 60637

Automobile Manufacturers Association, Inc.
320 New Center Building
Detroit, Michigan 48202

Citizens for Clean Air
40 W. 57th St.
New York, N.Y. 10019

Conservation Education Association
C/O Dr. W. F. Clark
Eastern Montana College
Billings, Mont. 59101

Ducks Unlimited
P.O. Box 8923
Chicago, Ill. 60666

x

Garden Club of America
598 Madison Ave.
New York, N.Y. 10022

General Federation of Women's Clubs
1734 N Street, N.W.
Washington, D.C. 20036

Izaak Walton League of America
1326 Waukegan Rd.
Glenview, Ill. 60025

League of Women Voters of the United States
1200 17th St., N.W.
Washington, D.C. 20036

League of Women Voters of Portland (Oregon)
308 Senator Building
732 S.W. Third Ave.
Portland, Oregon 97204

Men's Garden Clubs of America
Morrisville, N.Y. 13408

National Association of Counties
1001 Connecticut Avenue
Washington, D.C. 20036

National Association of Soil and Water Conservation Districts
1025 Vermont Ave., N.W.
Washington, D.C. 20005

National Audubon Society
1130 5th Avenue
New York, N.Y. 10028

National Council of State Garden Clubs, Inc.
4401 Magnolia Avenue
St. Louis, Missouri 63110

National Parks Association
1300 New Hampshire Ave., N.W.
Washington, D.C. 20036

National Recreation and Park Association
1700 Pennsylvania Ave., N.W.
Washington, D.C. 20006

National Tuberculosis Association
Oregon Association
830 Medical Art Bldg.
Portland, Oregon 97205

National Wildlife Federation
1412 16th St., N.W.
Washington, D.C. 20036

National Youth Conference on Natural Beauty and Conservation
C/O Girl Scouts of the U.S.A.
830 Third Ave.
New York, N.Y. 10022

Sierra Club
1050 Mills Tower
220 Bush St.
San Francisco, Calif. 94104

Society of American Foresters
1010 16th St., N.W.
Washington, D.C. 20036

Soil Conservation Society of America
7515 N.E. Ankeny Rd.
Ankeny, Iowa 50021

Sport Fishing Institute
719 13th St., N.W.
Washington, D.C. 20005

Trout Unlimited
5850 E. Jewel Ave.
Denver, Colorado 80222

Urban America
1717 Massachusetts Ave., N.W.
Washington, D.C. 20036

American Petroleum Institute
1271 Avenue of the Americas
New York, N.Y. 10020

American Conservation Association
30 Rockefeller Plaza
New York, N.Y. 10020

American Forest Institute
Education Division
1835 K St., N.W.
Washington, D.C. 20006

American Forest Products Industries
1835 K St., N.W.
Washington, D.C. 20006

The Conservation Foundation
1250 Connecticut Ave., N.W.
Washington, D.C. 20036

UAW-CIO Department of Conservation and Resource Development
8000 E. Jefferson Street
Detroit, Michigan 48214

Industrial Gas Cleaning Institute
Box 448
Rye, N.Y. 10580

Wildlife Management Institute
709 Wine Building
Washington, D.C. 20005

Keep America Beautiful
99 Park Ave.
New York, N.Y. 10016

American Association for the Advancement of Science
1515 Massachusetts Ave., N.W.
Washington, D.C. 20036

American Society of Agronomy
677 Segoe Rd.
Madison, Wis. 53711

Wildlife Society
Suite S-176
3900 Wisconsin Ave., N.W.
Washington, D.C. 20016

PERIODICALS

Air Pollution Control Association Journal

American City

American Forests

Atmospheric Environment

Audubon

B.C. Outdoors

Chemical and Engineering News

Current Science

Defenders of Wildlife News

Demography

Desalination

Ecological Monographs

Ecology

Environment

Environmental Education

Environmental Science and Technology

ESSA World

Food Production

Journal of Environmental Health

Journal of Forestry

Journal of Soil and Water Conservation

Journal of the Water Pollution Control Federation

Journal of Wildlife Management

Land Pollution Reporter

Living Wilderness

National Parks Magazine

National Wildlife Magazine

Natural History

Naturalist

Oceanology International

Oceans

Oregon Game Commission Bulletin

Outdoor World

Parks and Recreation

Pollution Abstracts

Population Bulletin

Population Index

Public Works Magazine

Radiological Health

Science

Science Activities Magazine

Science News

Scientific American

Sierra Club Bulletin

The Conservationist

The Science Teacher

Today's Health

Water and Wastes Engineering

Water in Oregon

Water Research

Water Resources Research

Western Conservation Journal

The Wild Cascades

LABORATORY MANUALS

Air Pollution Experiments for Junior and Senior High School Science Classes, Hunter and Wohlers, Editors, Air Pollution Control Association, 4400 Fifth Ave., Pittsburgh, Pennsylvania 15213, 1969. $1.

Air Pollution Experiments, High School Edition, Cooperative Extension Service, College of Agriculture and Environmental Science, Rutgers University, New Brunswick, New Jersey 08903.

Detection and Analysis of Particulate Contamination, Millipore Corporation, 1969. Free.

Experiments in Microbiology, Millipore Corporation, 1969. $0.50.

**Limnology: An Introduction to the Fresh Water Environment*, William H. Amos, LaMotte Chemical Products Company, Educational Products Division, Chestertown, Maryland 21620, 1969. $0.50

Microbiological Analysis of Water, Millipore Corporation, Educational Division, Ashby Road, Bedford, Massachusetts 01730, 1969. Free.

*The Oregon Science Teacher, November 1969 issue, c/o Thor Sabo, Hillsboro High School, 3285 S.W. Rood Bridge Road, Hillsboro, Oregon 97123. $0.15.

*Our Environment Battles Water Pollution, Charles E. Renn, LaMotte Chemical Products Company, Educational Products Division, Chestertown, Maryland 21620, 1969. $0.50

Scientific Experiments in Environmental Pollution, Elbert C. Weaver, Editor, Holt, Rinehart & Winston, Inc., 383 Madison Ave., New York, N.Y. 10017, 1968. $1.10.

Some Air Pollutant Estimation Techniques for the High School Science Student, Laboratory of Atmospheric Sciences, National Center for Atmospheric Sciences, Boulder, Colorado 90302.

*A Study of Soil Science, Henry D. Foth, LaMotte Chemical Products Company, Educational Products Division, Chestertown, Maryland 21620, 1969. $0.50.

*A Study of Water Quality, Charles E. Renn, LaMotte Chemical Products Company, Educational Products Division, Chestertown,Maryland 21620, 1969. $0.50.

*Environmental Education--Objectives and Field Activities, Major, Cissell, and others, Paducah Public Schools, Environmental Education, 10th and Clark Sts., P.O. Box 1137, Paducah, Kentucky 42001, 1969. Single copies free.

*Manual for the Outdoor Teacher, Knight, Hill, Freund, Tri-District Outdoor Education, 885 Evening St., Worthington, Ohio 43085, 1969. $2.00.

*These publications are not strictly laboratory manuals but are reported to contain experiments and activities along with other information.

BIBLIOGRAPHIES, DICTIONARIES, DIRECTORIES, LISTS, & CATALOGS

Environmental Education for Everyone, Bibliography of Curriculum Materials for Environmental Studies, National Science Teachers Association, 1201 Sixteenth St., N.W., Washington, D.C. 20036, 1970. $0.75.

Air Pollution Publications 1966-68 (PHS Publication No. 979), Public Health Service, U.S. Government Printing Office, Supt. of Documents, Washington, D.C. 20402, 1969. $4.50.

Available Curriculum Materials, A List, Golden Valley Environmental Science Center, 5400 Glenwood Ave., Minneapolis, Minnesota 55422.

1970 Conservation Directory, National Wildlife Federation, 1412 Sixteenth St., N.W., Washington, D.C. 20036, 1970. $1.50.

Conservation Education--A Selected Bibliography, Carvajal and Munzer, Conservation Education Association, Interstate Printers and Publishers, Conservation Books, Danville, Illinois 61832, 1968. $2.50.

Conserving Our Natural Environment, Public Library, Washington, D.C. 1967. Free reading and film list.

Catalog of Free Films on Air Pollution on Loan for Group Showings, U.S. Government Printing Office, Superintendent of Documents, Washington, D.C. 20402.

A Directory of Information Resources in the United States: Physical Sciences, Biological Sciences, Engineering, National Referral Center for Science and Technology, U.S. Government Printing Office, Superintendent of Documents, Washington, D.C. 20402, 1965. $2.25.

Ulrich's International Periodicals Directory; A Classified Guide to a Selected List of Current Periodicals, Foreign and Domestic. Volume 1: Scientific, Technical and Medical, R.R. Bowker Co., 1180 Avenue of the Americas, New York, N.Y. 10036, 1967. $15.00.

Dictionary of Ecology, Herbert C. Hanson, Philosophical Library, Inc., 15 E. 40 St., New York, N.Y. 10022, 1962. $10.00.

Paperbacks on Population, Family Planning, Related Subjects, Planned Parenthood-World Population, 515 Madison Ave., New York, N.Y. 10022, 1967.

"Bibliography on Air and Water Pollution" *Special Libraries*, v.57, no. 6, July-August 1966, p. 385-390, Special Libraries Association, 235 Park Ave. S., New York, N.Y. 10003. $1.50.

Composite List of Conservation and Related Subjects - Film Titles, 2nd ed. Conservation League, 110 W. 71 St., New York, N.Y. 10023, 1966. $0.65.

A Critical Index of Films and Filmstrips in Conservation; Dealing with Renewable Resources, Non-Renewable Resources, Resources and People, and Ecology, 3rd ed., Conservation Foundation, O'Hare Books, 10 Bartley Rd., Flanders, N.J. 07836, 1967. $1.00.

INTRODUCTION

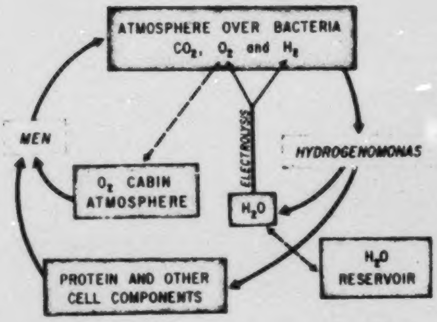
In the last chapter we studied two ecosystems which, although unified, were not isolated from their surroundings. There are also ecosystems which are almost completely isolated so that there is a negligible exchange of matter with the rest of the universe. Such systems are called closed systems (with respect to matter).

The simplest closed ecosystem is a space ship during a space voyage. In ships of the Apollo type, all consumables (food, water and oxygen) are stored in the vehicle before lift-off and all wastes (urine, feces and carbon dioxide) are collected and either stored or ejected from the ship. It is obvious that the lifetime of an Apollo ecosystem is quite short, since the amount of consumables which can be carried is limited, and they are only used once. What about long-range space voyages - star treks that last years? It is clear that in this case the spacecraft must be self-sustaining, that is, the consumables must be manufactured on board. But what raw materials can they be made from? There is only one possibility: from the waste products of the astronauts. In other words, since the maximum amount of matter on a space ship is fixed, it is necessary to recycle all waste material. Research on methods of recycling has been going on at National Aeronautics and Space Administration (NASA) centers for several years. Recycling of water essentially involves distilling and otherwise purifying the water in urine and other waste products. Oxygen can be obtained by the electrolysis of water.

$$2\ H_2O_{(l)} \xrightarrow[\text{Energy}]{\text{Electrical}} 2\ H_{2(g)} + O_{2(g)}$$

The subscripts are used to indicate the state of matter, i.e. (l) liquid, (g) gaseous. A 25% aqueous sulfuric acid electrolyte is used as a catalyst in the electrolysis.

A simplified version of the cycle of carbon and oxygen in such a system is as follows:


ATMOSPHERE OVER BACTERIA CO_2, O_2 and H_2
MEN
ELECTROLYSIS
HYDROGENOMONAS
O_2 CABIN ATMOSPHERE
H_2O
H_2O RESERVOIR
PROTEIN AND OTHER CELL COMPONENTS

Converting human wastes (feces, urine and CO_2)into food is not as simple. Here the intervention of living organisms is required, at least at the present time. One promising approach being investigated at NASA is the use of a special kind of bacteria, called Hydrogenomonas, that can grow on CO_2, H_2, O_2, NH_3, and other inorganic compounds. The bacteria are a rich source of protein and vitamins and conceivably could serve as food for humans.

As long as an energy source for distillation and electrolysis is available (for example, solar batteries) the cycle could continue to operate.

The other ecosystem we want to consider is also a space ship. It is called earth. It is much larger than man-made craft, and it has a much greater variety of living things, but it is

Note that the continued operation of this cycle requires the input of energy in the form of electricity still a closed system with a fixed and limited amount of matter in it.

In the following sections we will deal with some of the factors which affect the amount and distribution of the many forms that matter can take on earth.

and the discharge of energy in the form of heat, arising from the activity (metabolic and other) of the organisms. A description of life-support systems for extended space flights may be found in Environmental Problems, edited by B.R. Wilson, Lippincott 1968.

TEACHER NOTE

Recommended motion picture films are available from one or more of the sources listed below. The sources are referred to in the Teacher's Guide by number only (corresponding to the identification below) and this identification is followed by that particular film's catalogue number for that source. Any of the recommended films may, of course, be available in your local district media center, county film library or some other local source.

(1) Multnomah County Library
801 S.W. 10th Ave.
Portland, Oregon

(2) Audio Visual Instruction
Division of
Continuing Education
Gill Coliseum 133
Corvallis, Oregon 97331

(3) National Medical Audio-
Visual Center
Chamblee, Georgia 30005
(Order by title and number and request at least two weeks in advance of showing date.)

TEXT SECTION	ROUGH TIME ESTIMATES	EXPERIMENTS	DEMONSTRATIONS	TEACHING AIDS	OTHER STUDENT ACTIVITIES	OUTSIDE READING	PROBLEMS
Chapter I: Our Space Ship Earth	1 Day						
A. Cycles of Matter							
B. Manipulating the Cycles							HDL 44
B.1 The Effects of Fertilizers							

ENVIRONMENTAL BALANCE

Outline: Environmental Balance

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Chapter I: OUR SPACE SHIP EARTH

A. CYCLES OF MATTER

Just as with any well-designed, long-range spacecraft, the earth has the means of re-using waste material. Dead organic matter is being continually converted to inorganic compounds by the decomposers (bacteria, protozoa and fungi). If it were not for their activities, the earth would be engulfed with the carcasses of animals and plants--particularly the woody parts of plants, since microorganisms alone are capable of digesting cellulose and lignin. Once organic matter has been converted to inorganic material (carbon dioxide, nitrates, phosphates and sulfates), the producers (plants and algae) can reconvert the inorganic compounds to organic food for primary consumers. The primary consumers in turn become food for secondary consumers and so on up the food chain. This cycling of the elements of living matter between the organic and inorganic realms goes on continually, driven by the energy of the sun. The cycle of the most characteristic element, carbon, can be diagrammed as in Fig. 1.

Organic compounds are most carbon containing compounds.

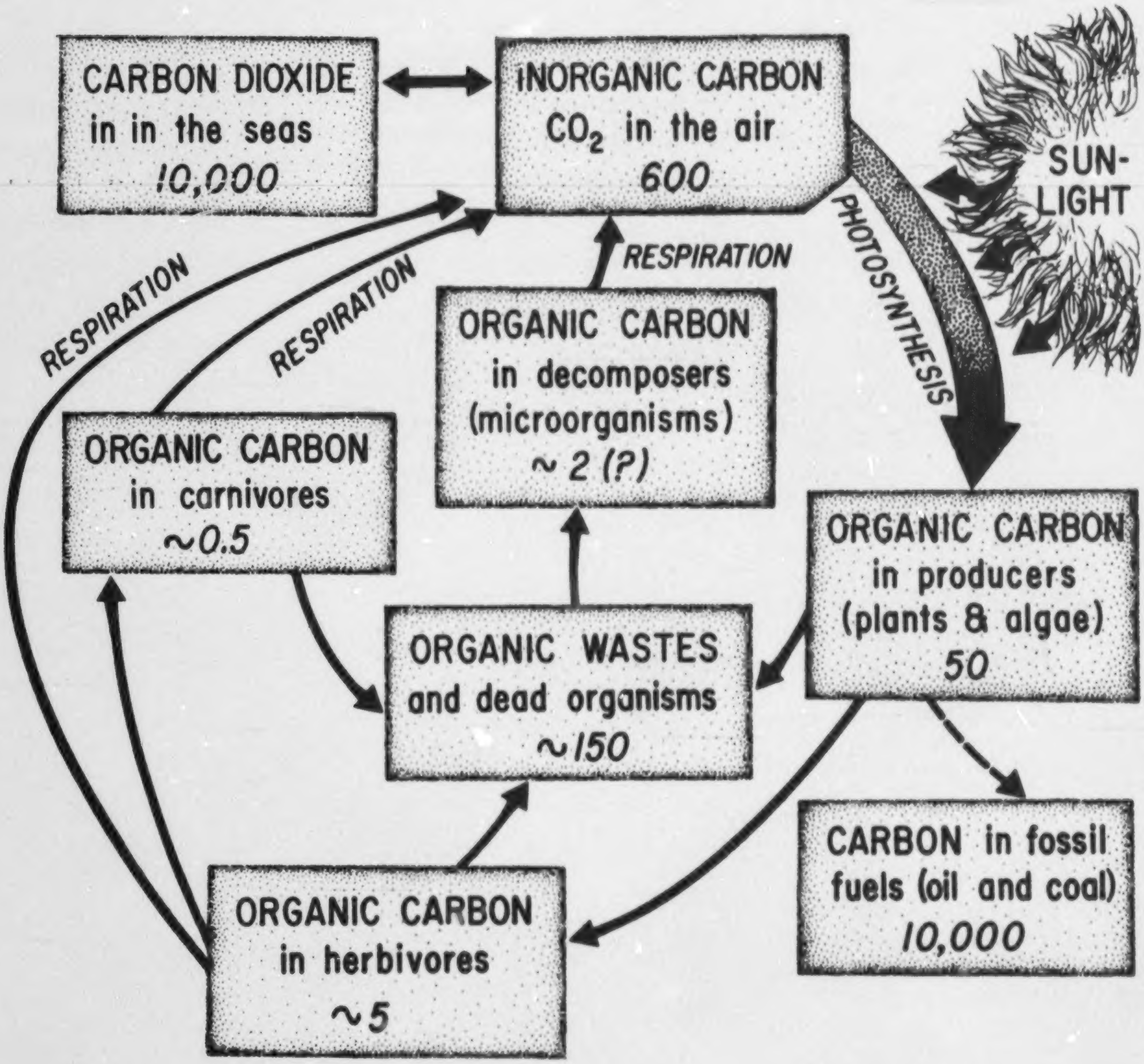

CARBON DIOXIDE in in the seas 10,000
INORGANIC CARBON CO_2 in the air 600
SUN-LIGHT
PHOTOSYNTHESIS
RESPIRATION
RESPIRATION
RESPIRATION
ORGANIC CARBON in decomposers (microorganisms) ~ 2 (?)
ORGANIC CARBON in carnivores ~0.5
ORGANIC CARBON in producers (plants & algae) 50
ORGANIC WASTES and dead organisms ~150
CARBON in fossil fuels (oil and coal) 10,000
ORGANIC CARBON in herbivores ~5

Figure 1

In the short run, the carbon cycle is balanced. That is, every year the producers convert about 30 billion tons of inorganic carbon to organic carbon, and every year the consumers and decomposers convert about 30 billion tons of organic carbon to carbon dioxide. If the cycle were not balanced the amount of organic carbon on earth would either increase or decrease, depending on which was greater, the rate of photosynthesis or the rate of respiration. About 300 million years ago conditions apparently favored photosynthesis over respiration. It was during this time that vast forests covered much of the earth, which led to the accumulation of large deposits of coal. At the present time the technological activities of man are returning this sequestered carbon to the cycle at the rate of 2 billion tons a year, so the amount of carbon dioxide in the air is increasing.

The other elements in organic matter, such as oxygen, nitrogen, phosphorus and sulfur, are also cycled between the inorganic and organic realms of the earth. For example, 80 billion tons of oxygen are consumed each year by animals and microorganisms in the oxidation of food and about 80 billion tons of oxygen are

These data were obtained from Ehrensrärd, Life: Origin and Development, University of Chicago Press, 1962, Chapt. 2. 95% of the conversion of organic C and CO_2 is carried out by microorganisms.

The effects of burning coal and oil on the world's climate are uncertain but potentially dangerous.

Burning fuels has two opposing effects on climate: warming as the result of the greenhouse effect of CO_2 and cooling as the result of increased reflectance of smoke and clouds.

The atmosphere contains a reserve of a million billion tons of oxygen. About 80 billion tons of oxygen are cycled each year.

produced each year by photosynthesis. It is important to realize that plants are not only the ultimate food source but also the source of oxygen on earth. Over half of the yearly production of oxygen comes from algae in the oceans, mainly concentrated in shallow waters over the continental shelves. Any massive interference with these algae by man's activities (for example oil spills) could affect the oxygen balance of our planet.

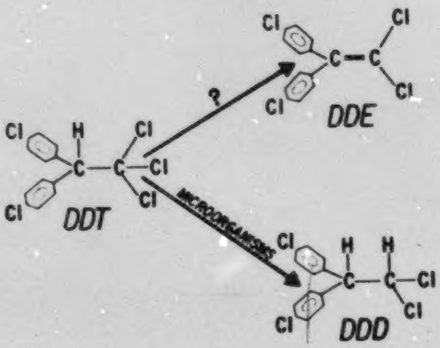
B. MANIPULATING THE CYCLES

The diagram in Fig. 1 does not remotely do justice to the enormous complexity and variety of forms organic matter can take. In the course of evolution the tendency has been toward increasing specialization, both of producers and consumers. The flow of carbon has fanned out into a multitude of parallel channels, and ecosystems have tended to become more and more elaborate.

But about 10,000 years ago man began to change the cycle of carbon by diverting more of the flow into his "channel." In other words, he invented agriculture. Agriculture is a technique by which certain producers are eliminated (certain trees and weeds) and other producers are deliberately cultivated (grains, vegetables, etc.). The net result is that a larger share of organic carbon is diverted to human beings, and the human population increases. Each advance in agricultural technology permits a further increase in population. At the present time the human population contains more than 0.03 billion tons of carbon and this quantity is doubling every 35 years or so. This weight of carbon is equivalent to 1% of that found in all animals or 10% of that found in carnivores. Further increases of our population will almost surely be at the expense of other organisms.

Man not only manipulates the carbon cycle by controlling the types of producers; he also assures himself a larger share by killing those consumers that compete with him for food. Rodents and insects are the chief competitors, and man attempts to deal with them by spreading poisons called pesticides in the environment. Unfortunately the pesticides so far in use are not sufficiently selective in their action. They poison desirable and undesirable species alike. Even worse, some pesticides, such as DDT, are not completely biodegradable, and hence they or some of their derivatives are accumulating on the face of the earth. It is

The processes, if they exist at all, whereby such pesticides as DDT are decomposed (to the point that they can be recycled) are not well understood. However, it has been found that DDT, for example, undergoes reductive dechlorination to either DDD or DDE. Beyond this, little is now known.



Both DDE and DDD retain toxic effects similar to those of DDT. Another chlorinated hydrocarbon, dieldrin, is generally considered to be the most stable and hazardous insecticide in our environment.

The most promising approach seems to be the identification and synthesis of insect sex attractants and hormones. These are exceedingly potent, species-specific, biodegradable, and hopefully not toxic to humans.

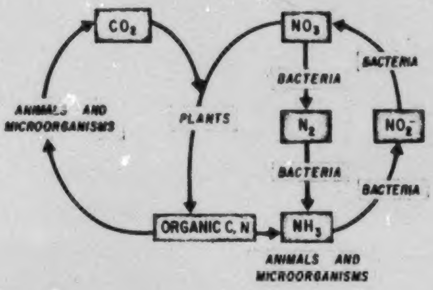
estimated that a billion pounds of DDT-type compounds has accumulated already. Fortunately the development of specific methods of insect control are underway and broad spectrum insecticides, at least, may soon be a thing of the past.

B.1 - THE EFFECTS OF FERTILIZERS

The rate of photosynthesis varies as much as 200fold from one area of the earth to another. There are many factors which affect this rate, such as temperature, amount of sunlight, etc., but probably the most important limiting factors are either the availability of water or of the fertilizers, nitrate and phosphate. Nitrogen and phosphorus are important constituents of living material, needed for growth of both plants and animals.

In modern agriculture, crop yields can be greatly increased by intensive application of fertilizer. World-wide use of modern agricultural technology would increase the annual rate of photosynthesis by a large amount, and this in turn would support a larger human population. But let's look at this process more closely. Man gets phosphate from rocks and ammonia from the nitrogen in air, and converts them to organic material (food) by agriculture. The phosphorus and nitrogen in food enter the bodies of people, where it can be used for growth. Any excess not used for growth is excreted and sent to sewage disposal plants. From there, in the vast majority of cases, the phosphate and ammonia are discharged into the nearest lake or river. But as we've already said, phosphate and ammonia are fertilizers. Hence, they fertilize the water and permit the growth of tremendous crops of algae, which in turn are decomposed by bacteria. The net effect of using fertilizer, then, is an increase in the total amount of organic carbon, but the increase is distributed between people, algae and bacteria. The increase in total organic matter in water is very beneficial to bacteria. They grow very rapidly, quickly use up the available dissolved oxygen,

It may be pointed out that all of the various cycles of matter are intermeshed. For example:

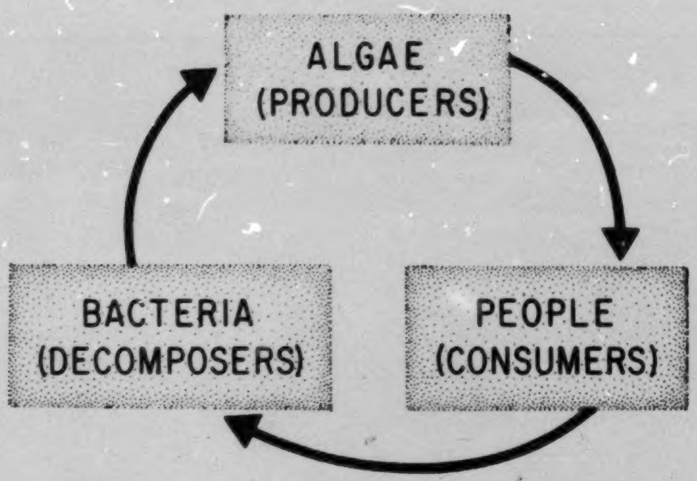


and continue to grow anaerobically (not requiring oxygen). However this situation is not very beneficial to fish and other aquatic animals, since they have become somewhat addicted to the use of oxygen.

To summarize, man has been intervening in the ecology of the earth for a very long time, and because of this intervention we have become the dominant species both in total amount of carbon and in influence upon the environment:

> We divert a larger and larger fraction of the flow of carbon to the production of human beings.
>
> We increase the total amount of organic carbon and the flow of carbon by intensive methods of agriculture.
>
> We kill living things that compete with us for food.

All of these actions have the effect of increasing the number of people and decreasing the numbers of most other organisms. If carried to their logical conclusion these policies lead to a three-component system:


ALGAE
(PRODUCERS)
PEOPLE
(CONSUMERS)
BACTERIA
(DECOMPOSERS)

It is clear that in a short time mankind is going to have to make a decision, consciously or unconsciously. That decision is: how many and what kind of passengers are we going to carry with us on Space Ship Earth?

TEXT SECTION	ROUGH TIME ESTIMATES	EXPERIMENTS	DEMONSTRATIONS	TEACHING AIDS	OTHER STUDENT ACTIVITIES	OUTSIDE READING	PROBLEMS
Chapter II: Pollution	2 Days			Film: The Third Pollution (23 min.) available from [(1)] [(2) (#4466)], and [(3) (#AM1404].	HDL 8,10,11, 46,54		HDL 7,12,23, 27
A. What is Pollution?							
A.1 Types of Pollution							
A.2 Beware of Pollution Illusions							
A.3 Pollution's Gray Area							
A.4 Risk versus Benefit							
B. Sources of Pollutants				Film: A Matter of Attitudes (30 min.) Available from [(3)(#M-1530-X)].	HDL 8,32,48.		HDL 33,34,49, 50,51.
B.1 Look Into A Mirror							
C. Definition of Pollution							

Chapter II: POLLUTION

As a result of his ability to control the cycles of matter, man has become the most successful animal on earth. His success is measured by the fact that his population has increased from an estimated 5 million 10,000 years ago to over 3 billion now. But he is in danger of becoming a victim of his own success. In order to support a rapidly expanding population, a rapidly expanding agriculture is required. This, in turn, demands an expanding, industrialized society to manufacture the sophisticated machines necessary to produce and distribute food. As industrial production continues to expand, the problem of waste disposal becomes more and more acute. Many of the things that become wastes are only very slowly decomposed. Metals, many plastics, glass and certain chemicals are not attacked by microorganisms, so they tend to accumulate in our environment. In addition, certain wastes present serious problems because they are poisonous to various forms of life. The problems of waste disposal would be much easier to solve if it weren't for the fact that the population is expanding. We have to run faster

This is an excellent time to show the film The Third Pollution, which examines a variety of solid waste disposal techniques.

and faster just to stay in the same place.

We are all exposed to information about pollution and the environment in the newspapers and magazines, on radio and television, at political rallies, and during meetings of various clubs and other organizations. To the same degree that everyone is traditionally in favor of the flag, motherhood, and apple pie, people are vehement in their denouncement of pollution. In fact, maybe we should be putting up various types of warning signs in public places. In some of our areas an appropriate sign might read "warning, breathing may be hazardous to your health." Compliance with a warning of this type presents slight problems, however. What is our option then as an approach to the pollution situation?

A. WHAT IS POLLUTION?

A.1-- TYPES OF POLLUTION

In an effort to attempt to define pollution, we need to become aware of the many aspects of the pollution problem. We find pollution of our air, water, soil, and foods. In these general areas, the pollution may take the form of chemicals, heat, radioactivity, solid waste, or sound, to mention just a few. Some people speak of population pollution, pollution of the mind, aesthetic pollution, and others as well.

In addition, we should be aware of the fact that not all pollutants have an equal effect upon the environment. Research has also shown us that the concentration of a pollutant is extremely important. The same pollutant in different concentrations has been found to have different effects in the environment both in terms of what things it interacts with and the severity of the interaction. Therefore when examining the pollution problem, we need to know specifically which pollutants we are speaking about and in what concentrations they exist and/or become of concern to us.

A.2 - BEWARE OF POLLUTION ILLUSIONS

We must be careful not to be fooled by our senses when examining the pollution problem. Earlier in the year we learned of some of the limitations and possible errors that can exist when we gather information by using our senses alone. For example, is a dirty-appearing river a polluted river? If so, how dirty does it need to appear before it becomes unacceptable to us? Are we basing our judgment on its appearance, its ability to be used as a public water supply, its effect on aquatic life, its ability to be used for irrigation purposes, its ability to be used for swimming, or on other considerations?

Any stream can be polluted, with or without visible evidence. Non-visible pollution could be due to infectious agents (including bacteria and viruses), organic chemicals such as pesticides, radioactive substances, or other mineral or chemical substances being carried by the stream, either dissolved or suspended.

Can a crystal clear, cold, sand bottom, rapidly running mountain stream be polluted? These questions should point out to you that we should not make hasty, superficial judgments when examining the various aspects of the pollution problem. We must make the necessary decisions only after gathering sufficient data concerning the aesthetics, uses, etc. of the particular situation.

A.3 - POLLUTION'S GRAY AREA

Another major consideration deals with situations such as the addition of fluorine to a public water supply. Some people, many scientists among them, consider this a preventive measure for dental health. Others consider this to be pollution of a public water supply. Who is right and who is wrong? Pollution means different things to different people, because we have not yet defined pollution in a manner meaningful to all citizens. The same type of considerations may arise regarding chemicals added as food preservatives, sugar substitutes, or coloring materials.

A.4 - RISK VERSUS BENEFIT

Often things are done in an effort to increase the standard of living, prolong the life of the individual, or in some related type of activity without full knowledge of their long-term effects upon people or of the immediate or long-term effects upon the environment. That is, the decision is made to take a risk, which is often unknown, in exchange for certain benefits. Perhaps in the future we should give greater consideration to environmental effects than we have in the past when making these risk versus benefit decisions. Some examples of this type of decision are the use of radiation in the treatment of cancer, nuclear testing, the use of various pesticides, and thermal-nuclear generation of electrical power.

Radiation is often an effective means of combating cancer, even though it is also believed to induce cancerous growths under other conditions. The dose given in treatment may well be determined by taking into account the age of the patient, the patient's age group life expectancy, etc. This procedure hopefully prevents injury due to the radiation during the expected lifetime of the patient.

Many experts consider nuclear testing to be a deterrent of nuclear war, and therefore see the health risk from fallout as acceptable for the benefit achieved.

Most people believe that the use of pesticides has contributed to the health, food supply, and comfort of mankind, but because of a lack of information on their behavior in nature, caution indicates that long-lived ones should not be needlessly released into the biosphere. However, they still appear to be essential in certain situations.

Thermal-nuclear generation of electrical power has some environmental risk involved in terms of cooling processes and disposal of wastes, as well as the possible effects of an operational accident.

B. SOURCES OF POLLUTANTS

B.1 - LOOK INTO A MIRROR

What are the sources of the various pollutants? The sources are many, but generally the pollution that concerns us most appears to be a man-centered problem, even though the effects are not limited to any one aspect of the environment. In fact, man's greatest enemy may be himself (and let's not forget that the term "man" includes each of us). The pollutants can be either the direct result of the biological functions of man and his other companions in the environment, or the result of the processes (industrial, etc.) that are functioning to maintain and improve the standard of living that man has come to experience and expect. Many of the pollutants are residues of things man makes, uses, and throws away. The quantity of these things increases both because of population increases and because of increasing expectations for higher living standards. For example, we have almost 100 million internal combustion engine vehicles in the United States, with no sign of decrease in sight. These are a source of pollution both during their operation by an individual and when the time comes for their disposal. However, pollution because of high living standards is a problem for only a minority of the world population.

C. EFFECTS OF POLLUTION

In later chapters you will have the opportunity to discover some of the specific effects of some pollutants, particularly those associated with our water and air. At this point, however, it is probably best to take a broad look at this aspect of the problem.

Generally speaking, pollution effects become of concern to us if they render the quality of something unfit for its intended use. We also become concerned if the pollutants interfere with either our own health or that of a rather selective group of plants or animals, or if they interfere with our comfort or safety. In addition, we become alarmed if they have a disruptive effect upon the maintenance, enjoyment or use of our property. In all probability, we have not displayed the ecological sensitivity that we should have up to this time. We should become concerned when the pollutants begin to affect the natural populations of the wide variety of life forms on earth or the operation of the myriad mass and energy cycles that all life is dependent upon. We should guard against becoming too man-centered.

D. DEFINITION OF POLLUTION

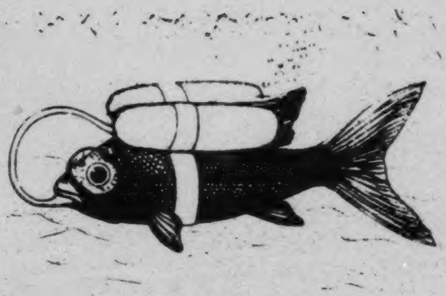
Before going on, a common working definition of pollution would facilitate discussion and study. Recognizing that this is a big order at this time, you should make use of all the resources available to you and then together with your classmates and teacher come up with a tentative working definition.

There are almost as many different definitions of pollution as there are articles, studies, or laws concerning it! An example of a legal type definition is found on page 44, where the legal definition of air pollution for the State of Oregon is reprinted. A rather general definition might be that pollution exists when the quality of the air, water, etc. is not satisfactory for its intended use. Very often definitions of air, water, and soil pollution indicate it exists when contaminants are strong enough to interfere with your comfort, safety, or health, or to prevent you from using and enjoying your property and your community. Dictionary definitions are generally geared towards references of making or rendering unclean, or to contaminate.

One satisfactory method of establishing a working definition for a class is to ask each student to bring in a definition, and then have the class select from these to formulate a composite working definition.

TEXT SECTION	ROUGH TIME ESTI-MATES	EXPERIMENTS	DEMONSTRATIONS	TEACHING AIDS	OTHER STUDENT ACTIVITIES	OUTSIDE READING	PROBLEMS
Chapter III: Water Pollution	1 Day						
A. Water							
A.1 Special Properties of Water							38
A.2 An Old Problem							
A.3 Overview of Water Pollution					HDL 8,47		1,2,3,4,14,16,17,19,20,22,24,25,26,39,49,52
B. Water Pollution					HDL 34,40,45,48,55		
B.1 Summary Chart on Water Pollution							
B.2 The Willamette River							
C. Where Does All Our Sewage Go?	1 Day				HDL 40,45 Field trip to a local sewage treatment plant.		HDL 39,49
	1 Day	(optional) Pollution Effects on *Daphnia*					

Chapter III: WATER POLLUTION



We do not have time to examine each of the various types of pollution in detail. However, we can investigate two of the most widely discussed in sufficient detail to give us some feeling for the scope of the problems that we face in all of the areas. Water pollution appears to be a good choice for one, since water is essential for life as we know it and is probably the single most important natural resource in the Pacific Northwest.

A. WATER

A.1 - SPECIAL PROPERTIES OF WATER

Water, that remarkable chemical compound which is a necessity for life as we know it, can dissolve so many substances that it is often referred to as the universal solvent. It dissolves various amounts of a wide variety of solid substances, such as sugars, salts, acids, bases, and metals, and will dissolve many gases, including oxygen, nitrogen, and carbon dioxide. The Niagara River carries over its famous falls, for example, an average of more than 230 million pounds of dissolved minerals each day. However, it doesn't always give them up again with the same ease. Fortunately, though, water is not permanently changed by the substances dissolved in it and can therefore be treated and reused. In addition to those substances that it dissolves, many substances can be transported in it as suspended or floating matter, while others sink to the bottom as sediment.

A.2 - AN OLD PROBLEM

We have been headed for a water quality crisis for years, and water pollution is as old as, if not older than, civilization itself. Silt is probably the world's oldest pollutant of water, since it was present long before man and has been aggravated by man's activities. Silt is nothing more than fine particles, such as soil or sand, that are suspended in or deposited by water. Each year, for example, the Mississippi River yields at St. Louis, Missouri, an average of 260 tons of sediment per square mile of land drained.

The rise of civilization and the grouping of people has brought about many of the problems of water pollution. It was about the middle of the 19th century before the role of polluted drinking water in the spread of diseases such as cholera, typhoid fever, hepatitis, and dysentery was discovered.

Water quality is influenced by both natural factors and by the activities of man. The natural quality of water varies from place to place, with the seasons of the year, with the climate, and with the kind of rocks and soil through which the water moves. The increase in population, urbanization, and growth and diversification of industry have contributed greatly to the increase in water pollution. Over the years many rivers became open sewers for municipal, industrial, and agricultural wastes. In the United States it was 1899 before the first recorded federal legislation to control water quality, the River and Harbors Act, was enacted. It prohibited the discharge or deposit into any navigable waters of any refuse except that which flowed from streets or sewers in a liquid state. As early as 1889, the Oregon Legislature passed a law which declared it illegal to pollute any waters used for domestic or livestock watering purposes. By 1936, Oregon had 48 separate and distinct laws relating to water pollution, but unfortunately they were not effective in controlling water pollution, due either to vagueness or failure to enforce them. In 1938 Oregon created a state agency (State Sanitary Authority) with responsibility for the control of water pollution; its goals included keeping the water of the Willamette system fit for salmonid fish (salmon and trout), suitable as sources of recreation, and usable for water supplies and other beneficial purposes. The 1938 legislation has been amended and strengthened by nearly every legislative session since 1953. In 1969 the State Sanitary Authority was renamed the "Department of Environmental Quality." Man has been reusing water all through the ages, either knowingly or unknowingly.

A.3 - OVERVIEW OF WATER POLLUTION

National water needs are increasing at a rate of about 30,000 gallons per minute.

The total use of water today in the United States is about 355 billion gallons per day, with an anticipated increase to about 600 billion gallons per day by 1980. The typical large city uses over 70 million gallons of water per day at the present time. Growing city populations and the soaring volume of industrial discharges into municipal sewers have placed a steadily mounting load of wastes on waters everywhere.

By water quality we mean the physical, chemical and biological characteristics of the water. Obviously, quality satisfactory for one use may not be for another.

As a result of many years of adaptation and change, we have today natural types of plants and animals in well balanced population densities, which are characteristic of most water bodies. One major role of water pollution control is to keep the quality of the water such that these naturally balanced populations will not be upset or annihilated. With this thought in mind, we need to remember that for the protection of fish, for example, it is essential to protect the whole array of other living things in the environment which compose the network of food cycles and chains leading up to the fish. This would include bacteria, algae, water plants, clams, snails, crabs, insects and most other water life. Water quality must be associated both with the intended use of the water and the maintenance by man of these balanced natural populations.

Pollution may take the form of offensive odors and sights, such as rotting algae and fish or floating debris of various types. Algae is often considered to be the cancer of water pollution, since pollution often spurs wild growth of these plants. Polluted water may contain invisible dangers in the form of harmful bacteria, viruses, radioactive wastes, chemicals; may be devoid of sufficient oxygen; or may be contaminated by heat pollution. Signs indicating that beaches have been closed to swimming and fishing serve as a harsh reminder of the presence of these not so obvious pollutants. Lakes, streams, bays, estuaries, and underground waters may all be affected.

A DO (dissolved oxygen) level of 3-5 ppm is accepted as about the lowest limit for the support of fish life over a long period of time.

There are several terms frequently used in discussions of water pollution that the informed citizen should be aware of. The first of these is the dissolved oxygen (DO) content. This is simply a measure of the amount of oxygen that is dissolved in the water, a quantity which is vital to the life processes of many different types of living organisms. The DO is generally expressed in terms of the number of parts per million (ppm) of oxygen that are present. In unpolluted waters, oxygen is usually present in amounts of 10-14 ppm. Another frequently used term is the biochemical oxygen demand (BOD), which expresses the quantity of dissolved oxygen required to remove waste organic matter from water in the process of decomposition by aerobic (oxygen using) bacteria. This is also measured in ppm. Effluent is a term that refers in general to any liquid which flows out of a containing space, and it may be sewage or industrial waste (either in its natural state or partially or completely treated) or any one of a wide variety of other liquids. Frequently reference is made to the bacterial or coliform count. This is a determination of the number of fecal coliform organisms (_Escherichia_ _coli_)present in the water. This count is an indicator of the possible health hazards that may result from contact with the water.

It is interesting to note that while pollution decreases the amount of water of suitable quality, continued growth of populations and industry means an ever mounting demand for clean, usable water. In general, it appears that the major causes of water pollution are excessive municipal, industrial, and agricultural waste loads and faulty land- and water-- use practices. These terms are further explained as follows:

Municipal Sewage and Wastes - Virtually everything that goes down the drain of a community and into its sewer system.

Industrial Wastes - Includes the acids, chemicals, and animal and vegetable matter that are produced by the paper, steel, meat processing, and other industries.

Agricultural Wastes - Silt from erosion, fertilizers, pesticides, returning irrigation water, and runoff from feedlots.

Land-use Practices - The manner in which our land is used and managed, including such diverse activities as mining, farming, timber cutting, and land development for homes and industry.

Water-use Practices - The manner in which our water is used and managed, including such activities as site selection and dam construction, reservoir management, navigational considerations, and hydroelectric and thermal-nuclear power generation.

B. VARIETIES OF WATER POLLUTION

B.1 - SUMMARY CHART ON WATER POLLUTION

The chart which follows contains information concerning some common pollutants, their sources, and their effects.

POLLUTANTS	Sewage and other oxygen-demanding wastes (decomposable organic wastes).	Infectious agents (including bacteria and viruses).	Plant nutrients (principally nitrogen, phosphorus, and carbon).	Organic chemical exotics, detergents, pesticides, etc.).
SOURCES	Municipal wastes (including water craft) Industrial wastes Agricultural wastes	Municipal wastes Agricultural wastes (including run-off from feed lots)	Agricultural wastes (including irrigation return) Municipal wastes Industrial wastes	Agricultural wastes (including irrigation return) Municipal wastes Spraying for agricultural and forest pest and weed control.
EFFECTS	Produces oxygen deficiency, which affects aquatic life and aesthetics.	Disease-causing organisms which are dangerous to human and animal health, producing such diseases as typhoid fever, cholera, hepatitis, and dysentery. Can affect use for municipal, industrial, and agricultural purposes, as well as recreation and aesthetics.	"Fertilize" aquatic plant life such as algae and water weeds. When these excess plants die and decay, it causes secondary oxygen-demanding.	Persist in water for long periods of time and are not readily removed by conventional waste treatment or water purification. Some have toxic effects on various forms of life. Affects use in municipal and agricultural areas, as well as aquatic life and recreation.

SUMMARY

	Other mineral and chemical substances (salts, metals, acids, manufactured chemicals, petroleum products)	Sediments (primarily soil and mineral particles)	Radioactive substances	Heat
	Agricultural wastes (including irrigation return) Industrial wastes (including mining and plating) Watercraft	Agricultural wastes Industrial wastes (logging, mining, forestry, construction industry)	Industrial wastes (waste products of mining and refining of radioactive minerals or as wastes of use of these products in industry and research, including thermal-nuclear power generation.) Fallout from nuclear testing.	Thermal and thermal-nuclear power generation and Industrial cooling. Irrigation (if it reduces normal stream flows) Irrigation return Dam construction and Pooling.
	Some toxic effects. Total effects are often subtle and not understood. Does affect aquatic life, as well as recreation use and aesthetics.	Changes the composition of river bottom and produces turbidity. Affects aquatic life, recreation, aesthetics, and industrial and municipal uses.	Health hazard. Affects aquatic life and limits use for recreation, industrial, municipal, and agricultural purposes.	Affects aquatic life (decrease in dissolved oxygen, effect on reproductive capacities, migration of fish, etc.)

B.2 - THE WILLAMETTE RIVER

The Willamette River, to consider our own area, becomes polluted each summer. This condition has existed for more than four decades, even though the intensity varies each summer. The Willamette watershed supports two-thirds of Oregon's population and provides an equal proportion of its industrial output. According to a 1967 Department of the Interior report, one of the most serious conditions of water pollution in the Pacific Northwest occurs in the lower reaches of the Willamette River. Because of this, the Willamette itself has been largely rejected as a water supply source, recreation has been curtailed, and the whole river below Eugene has at times exceeded bacterial limits for water contact recreation. This same area also has growths of slimelike bacteria (Sphaerotilus), bottom sludges, and floating sludge rafts.

As in other places, these conditions are due in large measure to industrial expansion, population growth, and urbanization, which have added up to increased wastes along the river. Some of the major industrial polluters have been the pulp and paper mills and food processing plants, all of which deposit water

There are contradictory reports concerning the degree of pollution of the Willamette River from a wide variety of agencies and persons. Current newspaper articles and agency news releases are probably the best way (next to a call to the agency itself) to keep up to date.

In 1939, there were less than 50 sewage treatment plants in operation in the entire state, only 23 in the Willamette Basin, and none on the main stem of the Willamette. Raw sewage from nearly a million persons was being discharged daily into the rivers and streams of the state.

It was 1947 before the first sewage treatment plant on the main stem of the Willamette was placed in operation. By 1957 all cities on the Willamette River had installed at least primary treatment, and in 1969 all had the equivalent of secondary treatment and effluent disinfection. By July 1972 all cities in the state will be required to have a minimum of secondary treatment and effluent disinfection equivalent to 85% reduction of oxygen demand and suspended solids.

Two excellent references are "Oregon's Water Pollution Control Program" (December 1969) and the Oregon State Board of Health Bulletin (Vol. 47, No. 9, September 1969), which are both available from the Oregon State Department of Environmental Quality.

high in dissolved organic materials that exert a heavy demand (BOD) on the dissolved oxygen resources. Other contributing causes have been gravel washing, road construction, logging, and improper forest and agricultural land management practices. Agricultural wastes, including both irrigation return and runoff, have added to the total problem. Municipal wastes contribute a large share to the problem, as well as the wastes from various vessels and houseboats. Summer streamflow is critical, and reservoir storage and regulation plays a major role in its maintenance.

The real challenge in the Willamette watershed, as elsewhere, is to maintain an adequate supply of water of suitable quality while protecting the ecosystem of plants, animals and man. With so many variables, it is easy to see how actions taken to combat one type of pollutant may have direct or indirect effects upon some or all of the others. When you expand this idea to include other types of pollution, you can begin to see the complexities of an attack upon pollution problems.

The most pressing needs for water pollution abatement seem to be waste reduction facilities for pulping and papermaking equivalent to con-

Pulp mills in the Willamette Basin now have year round treatment for removal of sedimentary solids, and all are required to have chemical recovery and secondary treatment by July 1972.

Improvement in DO content in the Portland Harbor has been significant, as witnessed by the State Sanitary Authority *figures shown below:*

	DO in ppm	
Year	*Minimum Monthly*	*Minimum Daily*
1957	*1.5*	*0.6*
1963	*3.0*	*2.0*
1965	*3.2*	*2.2*
1967	*3.3*	*2.6*
1968	*5.2*	*3.8*
1969 (to Aug. 10)	*5.6*	*4.6*

If at all possible, a field trip to a sewage treatment facility should be scheduled. Several excellent references concerning sewage treatment are indicated below, even though you may be able to obtain more applicable material for your own situation from a local agency.

A Primer on Waste Water Treatment. U.S. Dept. of the Interior, Federal Water Pollution Control Administration. Order from the Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402. This October 1969 publication is priced at $.55 each, but your nearest regional office of the Federal Water Pollution Control Administration may be able to provide you with some free copies.

A Primer on Water Quality. U.S. Dept. of the Interior, Geological Survey. Order from the same adress as above.

"How a Sewage Treatment Plant Works." This free pamphlet can be obtained from the Water Pollution Control Commission, P.O. Box 829, Olympia, Washington 98501.

ventional secondary waste treatment (essentially removal of floating and settleable solids and reduction by at least 85% of the biochemical oxygen demand), effective secondary treatment by communities where it does not already exist, and updating of waste treatment facilities in communities where they are either outmoded or overloaded.

C. WHERE DOES ALL OUR SEWAGE GO?

A vital process of interest to everyone is sewage treatment. It represents our major safeguard against the pollution of our waters and the subsequent upsetting of natural balances. It can vary from no treatment at all through a series of successively more complex treatment steps referred to as primary, secondary and tertiary. Talk of quaternary or even more sophisticated treatment is being heard more frequently as our water usage increases.

Hopefully, you will be able to visit a sewage treatment facility in your community, where you can observe first-hand the type of treatment your community gives its wastes. An understanding of the processes involved in treatment is significant both for the scientific value of the chemical and physical changes occurring and the knowledge of what facilities and expenses are necessary for treatment. It seems reasonably safe to say that no city or industry has yet installed the ultimate pollution abatement system. Therefore we will be asked to finance future installations. This will show up both in increased cost of consumer products and at the polls, where citizens will be asked to finance improvements. Are you willing to pay the price to insure the quality of water that is necessary?

D. OPTIONAL EXPERIMENT: POLLUTION EFFECTS ON *DAPHNIA*

Now that we have read and talked about water pollution, let us do some laboratory work. We should be aware of the fact that various pollutants in the same concentration affect different organisms in different ways, if they affect them at all. In addition we should realize that different concentrations of the same pollutant have different effects even upon the same organism.

We will make some observations of the effects of various pollutants and concentrations of these pollutants on the invertebrate *Daphnia* (water flea), an easily observed organism that is commonly found in fresh water ponds and lakes.

Your teacher will instruct your group as to what pollutant(s) you are to use and in what concentration(s). When observing, using either a low power compound microscope or a stereoscopic

Material and Equipment

Daphnia from pond water or from a biological supply house.
Microscopes, compound or stereoscopic.
Microscope slides, depression preferably.
Coverslips
Pipettes (medicine droppers)
Stopwatches or watches with sweep second hands.
Thermometers
Ice
Chemicals: see comments below.

The purpose of this experiment is to observe the effects (particularly in regard to the heartbeat) that changes in the aquatic environment have on the living organism. Secondarily, the students will have the opportunity to observe the living invertebrate heart.

This experiment offers the teacher great flexibility, allowing him to keep within the framework of the course and still respond to the interests of his students. It is designed to be performed with Daphnia (preferably Daphnia magna, although Daphnia pulex and D. longispina will also work), but tubifex worms or mosquito larvae should also succeed. It can easily be completed in one laboratory period.

If depression slides are not available, particles of broken glass can serve to keep the animals from being crushed by the coverslip. The Teacher's Manual (p.155) and Student Lab. Guide (p.179) for Yellow Version BSCS are excellent references *for this experiment.*

Average heartbeat in room temperature water is 275-325 beats per minute.

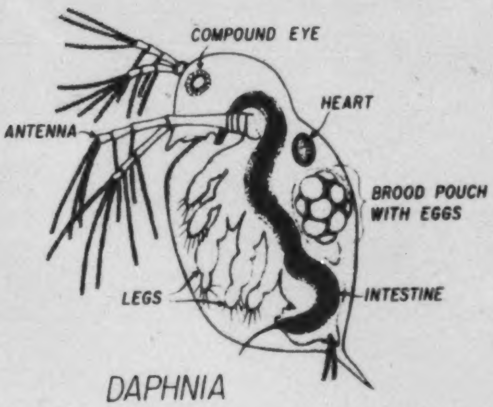
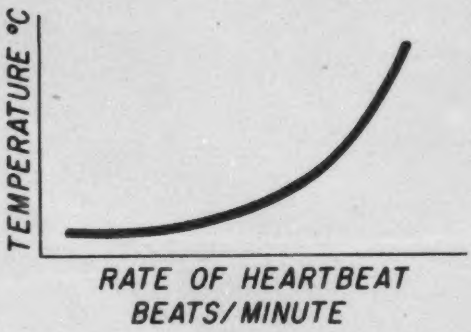


Figure C.1

Lower temperatures reduce the heartbeat rate; usually changes in rate are not equal for increasing 5° temperature intervals. A temperature versus rate of heartbeat graph would look something like that below.



microscope, remember to include in your data as much information as possible, such as rate of heartbeat, amount of movement, antenna movement, etc.

At least two students per lab group will be required, since the normal heartbeat is very rapid. A satisfactory method for measuring this is for the observer to tap a pencil with each beat of the heart, making dots on a piece of paper. Preferably the dots will be in a line that goes back and forth, so that they can easily be distinguished from one another. One partner can watch the Daphnia and tap while the other watches the clock for 15 seconds, then calls "stop." By counting the dots and multiplying by 4, the heartbeat will have been measured in beats/minute. An average of three trials under each condition should provide good results. Remember that there will be considerable variation between different individuals.

For many students this experiment may provide an opportunity to study heat pollution. The heartbeat rate at 5° C intervals from ice water to nearly boiling could be measured. Daphnia can either be placed into water on the slide at the desired temperatures or small beakers of water with the animals could be brought to the desired temperatures, then the animals transferred for observation.

You also have the opportunity to discover the effects of varying concentrations of pollutants upon an organism; this is one aspect which is often overlooked in pollution discussions. It might even be possible to determine the LD_{50} (dose lethal to one half the observed population) for particular pollutants regarding Daphnia. Your teacher will have available several materials from which to choose.

During your class summary keep in mind that the results you have obtained apply only to this organism. Might they apply to others? How could you determine the effects on other organisms?

We have looked only at short range effects. How could we study long range effects? If you have time, you may wish to do further study in one of these areas.

Perhaps the most drastic change in heartbeat rate can be produced by observing the organisms in various concentrations of alcohols. It can be reduced to as low as 10-30 beats/minute at high concentrations.

There are numerous other substances you might wish to work with or some students might wish to pursue during their independent study time. Some of these might be

- *pulp mill or other industrial discharge*
- *fertilizers*
- *detergents*
- *pesticides (many are toxic)*
- *salts*
- *acids*
- *bases*
- *petroleum products*
- *sediments*

Varying concentrations of saltwater also reduce the heartbeat rate, but the organism is killed at moderately high concentrations. The heart begins to palpitate, making counting difficult, before the lethal concentration is reached.

TEXT SECTION	ROUGH TIME ESTIMATES	EXPERIMENTS	DEMONSTRATIONS	TEACHING AIDS	OTHER STUDENT ACTIVITIES	OUTSIDE READING	PROBLEMS
Chapter IV: Air Pollution	1 Day			Film: Pollution (3 min.) [(3)(M-1529-X)] Excellent Introductory film.			
B. Air Quality					HDL 8,32,33, 36,37,41,42, 43,47,50,55		5,6,13,30, 33
C. Effects of Air Pollution					HDL 35		9,15,53
D. $$$ and Air Pollution							5
E. Air Pollution							
E.1 Summary Chart on Air Pollution							
	1 Day	F. Experiment: Two Types of Pollutants					

Chapter IV: AIR POLLUTION

UGH! WHEN ARE YOU GOING TO STOP POLLUTING THE CAVE, WIFE?

The second type of pollution to receive special attention in our study is air pollution. Air pollution is not new, being reported as early as 61 A.D. in Rome. Here in the United States, Indians called the area where Los Angeles now sprawls out "a land of many smokes." A smoke-abatement law concerning the use of coal in London was passed in 1273.

A. Air

Air is essential to our existence and is a necessity in sustaining the biological world in which we live. You need approximately 15,000 quarts of air each day for survival, and you inhale and exhale roughly 20 cubic feet of air per hour. Our lives depend upon a steady supply of oxygen moving from the lungs to the blood, and the equally steady removal of carbon dioxide from the blood by the lungs. There is an envelope of air about 250 miles thick surrounding the earth, but only the bottom 12 miles of this layer is dense enough for most of our needs. Actually a still thinner layer, about 2,000 feet thick, supplies most of the air we can use and breathe.

Population concentrations in urban areas and steamrolling technological developments have depleted and changed the composition of our "fresh" air.

B. AIR QUALITY

The quality of the air at any particular location is determined by many factors, among them the pollutants present and their concentrations, weather conditions and patterns (which affect the capacity of the atmosphere to dilute and disperse the pollutants), and geographic features. Just what then is air pollution? Oregon law defines it as follows: "Air pollution means the presence in the outdoor atmosphere of one or more air contaminants, or any combination thereof, in sufficient quantities and of such characteristics and of such duration as are likely to be injurious to public welfare, to the health of the human, plant or animal life or to property or which unreasonably interferes with the enjoyment of life and property throughout the state or throughout such areas of the state as shall be affected thereby."

Taking all of the above factors into consideration, a good method of control would appear to be regulating sources of the pollutants. Natural processes (such as dust storms, forest fires, and plant pollination) emit pollutants, as well as a wide variety of human operations, such as road building, logging, pesticide spraying, field burning, imperfect burning of fuels and other materials, and a wide variety of industrial, commercial, agricultural, and domestic operations. Once in the air, primary pollutants can become involved in chemical and physical activities that often result in more compounds, some of which are more dangerous than those originally discharged. The Los Angeles type of smog is the product of a photochemical (chemical reaction involving sunlight) process involving certain airborne chemicals. Those American cities with the most severe air pollution problems at the present are Chicago, Cleveland, Los Angeles, Long Beach, and New York. How far behind is Portland?

Oregon's geography tends to give it a high potential for air pollution. Inland valleys, such as the Willamette Valley, are especially subject to temperature inversions in which a warm air layer forms a "lid" over the area, thereby affecting the ability of the air to

There appear to be two choices:

(1) Removal or treatment at the source.

(2) Treatment prior to use.

Photochemical smog is a complex mixture of gases and particles (including ozone, peroxyacyl nitrates, etc.) manufactured out of nitrogen oxides and hydrocarbons by sunlight. Coal and oil containing elemental sulfur as an impurity produce some sulfur trioxide (as well as the more prevelant sulfur dioxide) which in the atmosphere immediately converts to sulfuric acid.

It is very difficult to tell just where Portland stands regarding the severity of its air pollution problems relative to other cities, but it has not yet gained ranking in the top 25.

dilute and disperse pollutants. In Portland, for example, inversion conditions occur in the early morning 83% of the time, or slightly over 300 days each year.

Industry is the most visible, most publicized, most criticized, and perhaps the most easily controlled source of air pollution, but over two hundred million experienced air pollution practitioners are alive and operating in the United States, and each of us falls into that category. This task force of polluters is armed with millions of automobiles, fireplaces, gasoline-powered machines, incinerators, houses to heat, etc., and constitutes an important source of air pollution that is seldom regulated or controlled and is responsible for well over half of our air pollution contaminants.

An excellent general reference concerning air pollution is The Effects of Air Pollution. This Public Health Service Publication No. 1556, Revised 1967, can be obtained from the Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at $.45 each.

C. EFFECTS OF AIR POLLUTION

Government economists have estimated the cost of property damage due to air pollution to be over $11 billion annually, not including damage to crops and grazing animals or the expenses involved in impairment to health. Of course, in some cases, the major impact may be aesthetic or psychological rather than economic. Some of the more obvious external effects are eye irritation, ruining of nylon fabrics

Exact data on the cost of property damage are not available, but the most frequently used estimate is $65 per capita per year, which would put the cost to the nation over $12 billion in 1970. The cost of wasted fuel is often overlooked, but it is estimated that the annual dollar cost in wasted fuel of all types runs into the billions, which may make it the costliest of all economic effects of air pollution. A 1967 report indicates that at today's prices, the wastage of the and other synthetic materials, decreased visibility, unpleasant odor and death of birds and other organisms.

Medically recorded disasters associated with atmospheric pollution are numerous, with eight major ones resulting in 6642 deaths and extensive illness. Two of the eight were in the United States, at Donora, Pennsylvania, and New York City, New York. There is also growing evidence that the effects of long-term, low-level air pollution are extremely far-reaching. Prolonged exposure to low concentrations of pollutants affects principally the respiratory system and appears to be associated with the common cold and other respiratory infections, chronic bronchitis, emphysema, chronic constriction of breathing passages, asthma, and lung cancer. Furthermore, the added external breathing effort caused by chronic constriction can have serious consequences for persons whose heart or lungs are already functioning marginally. All of these effects may often be the result of an interaction of many different pollutants rather than the result of a single pollutant.

sulfur found as an impurity in most fuels costs us as much as $300 million per year, not taking into account the effects the sulfur has when released into the environment as a pollutant.

When it is indicated that deaths or illness are attributable to air pollution, it means that there is an increase over the expected deaths or illness (for a measurable period of time) that can be statistically correlated to some type(s) of air pollutant.

The four day Donora incident was in October, 1946, and resulted in 20 deaths and 1/3 (6000) of the population made ill.
New York City really had two incidents, one in 1953 and another in 1962. The latter resulted in 400 deaths attributed to it.

D. $$$ AND AIR POLLUTION

The U.S. Department of Agriculture recently estimated the annual loss in crop damage due to air pollution at 500 million dollars. Fruit, for instance, may be affected in terms of quality, texture, and size. In some cases, crops and other vegetation can be killed directly. Sometimes pollutants are selective in terms of plants they damage, and therefore various plants can be used to identify air pollutants. In addition, the extent of the injury often gives a rough estimate of the concentration of the pollutants.

The figure given for crop damage includes losses due to damage to livestock, growing crops, and other plants and trees.

Air pollutants can cause an accelerated deterioration of materials and machinery, resulting in increased maintenance and replacement costs as well as depreciation of property values. Gaseous pollutants can corrode or tarnish metal, weaken and fade fabrics, weaken and rot leather, discolor paint, crack rubber, and ruin the precision instruments and complex control systems essential to modern technology. Airborne particulate matter soils buildings, clothing, rugs, and furniture, and can seriously damage some fine instruments. Smoke, haze, dust, and smog constitute a hazard to various types of transportation because of impaired visibility. Aesthetics and recreation are other areas which suffer because of air pollution.

E. AIR POLLUTION

E.1 - SUMMARY CHART ON AIR POLLUTION

The chart on the next page summarizes most of the air pollution problems that we face here in the Portland area, indicating the types of pollutants, sources, and possible effects.

More specifically, the sources of this air pollution in the Columbia-Willamette Air Pollution Authority area can be broken down as mobile sources (automobiles,etc.) 63%, manufacturing and commercial processes 20%, solid waste disposal (when burned) 11%, and space heating 6%.

F. EXPERIMENT: TWO TYPES OF POLLUTANTS

As you now realize, we are concerned with two general types of air pollution--particulate and gaseous. We will do some laboratory work that will allow us to examine some aspects of each type.

Part 1: PARTICULATE MATTER

In order to examine some of the particulate pollutants in your area, each of you will use a small piece of acetate that has an adhesive on one surface. Determine the area and mass of

Materials and Equipment

Part I: Particulate Matter
- *acetate-adhesive material*
- *balances, Mettler or analytical type desirable*
- *microscopes*
- *masking tape*

Part II: Gaseous Matter
- *smoking machines (see below)*
- *cigarettes*
- *gas detector tubes (see below)*
- *syringes*
- *surgical tubing or one-hole rubber stopper*

Part I: Particulate Matter

Probably the most convenient materials for capturing particulate matter are either Dennison

AIR POLLUTION SUMMARY

POLLUTANTS	Carbon Monoxide (CO)	Oxides of Sulfur (Primarily SO_2 and SO_3)	Hydrocarbons (Compounds of Carbon and Hydrogen)	Oxides of Nitrogen (Primarily NO and NO_2)	Other Gases & Vapors (i.e. iron oxide, peroxyacyl nitrates, CO_2, ozone, mercury, formaldehydes, aliphatic aldehydes, and acrolein)	General Particulate Matter (Smoke, Dust, Vapors, Soot, and Ash)	Miscellaneous Particulate Matter (Pollen, radioactive particles, arsenic, asbestos fibers, beryllium, cadmium, lead, sand, fluorides, etc.)
EFFECTS	Reduction in the oxygen carrying capacity of the blood, which can produce headaches, dizziness, slowing of physical and mental activity, and/or death.	Sensory irritation. Respiratory irritation and/or aggravation of existing respiratory diseases (including contributing to their development). Injury to delicate lung tissue. Plant damage. Visibility reduction. Corrosion.	Sensory irritation. Plant damage. Visibility reduction. Some will react with nitrogen oxides photochemically to produce smog.	Sensory irritation. Respiratory irritation. Plant damage. Visibility reduction. Sometimes responsible for the brown haze of cities. Odor. Can react with hydrocarbons photochemically to produce smog.	Sensory irritation. Respiratory irritation and/or aggravation of existing respiratory diseases. Breathing difficulty. Fatigue. Plant damage. Damage to textiles and and rubber.	Respiratory irritation and/or aggravation of existing respiratory diseases. May carry other pollutants deep into the lungs. May serve as catalysts for chemical reactions in the atmosphere. Most visibility reduction problems. Can accelerate corrosive action of other pollutants. Staining, soiling and corrosion.	Some are toxic. Possible impairment of the nervous system. Surface irritation to skin and mucous membrane. May carry other pollutants deep into the lungs. Respiratory irritation and/or aggravation of existing respiratory diseases. Possible radiation contamination and sickness. Odor, staining, soiling and corrosion. Plant and animal damage. Visibility reducation. May serve as catalysts for chemical reactions in the atmosphere. Can accelerate the corrosive action of other pollutants.
SOURCES	Incomplete burning of carbon containing materials and fuels. The primary contributor is the automobile.	From the burning of fuels(primarily coal and oil) that contain elemental sulfur as an impurity. The sulfur burns also, forming sulfur dioxide (SO_2) and sulfur trioxide (SO_3), which in the atmosphere immediately converts to sulfuric acid (H_2SO_4).	From the incomplete burning of most fuels which allows hydrocarbons to escape. The major single source is the automobile. Evaporation of fuels and solvents is also a significant source.	At the high temperatures normally associated with the burning of fuels, nitrogen in the air combines with oxygen to form nitric oxide (NO), which usually converts in the atmosphere to nitrogen dioxide (NO_2).	From photochemical reactions or a wide variety of industrial processes and burning.	Some from natural processes, such as dust storms, wind blown pollen, etc., but most of these are released as a result of man's activities (mostly industrial processes and fuel burning).	

GENERAL COMMENTS: All of the above pollutants, to a greater or lesser degree, are believed to pose a threat to human health, as well as the health of a wide variety of plants and animals. By far the largest contributor of contaminants is the automobile (just under 2/3 of the total pollutants in metropolitan areas). Space heating (residential and commercial), solid waste disposal (when burning is involved), and commercial and industrial sources (i.e. lumber industry, metallurgy, roofing material manufacturers, and rendering plants) account for most of the remaining pollutants.

your acetate sample. Your class will then decide how they can best be distributed within your school and community. At the assigned time and in the assigned place, remove the backing from your sample and secure it, as directed by your teacher, for the length of time established. At the end of this time bring your sample back to class, protecting it from dust and foreign matter by replacing the acetate backing, and mass it. Has its mass increased? If so, what was the mass increase per unit area? How did the mass increase per unit compare in the different locations? If there were any differences, what might have been the cause(s)? Some of you may wish to put out acetate sheets for collection purposes only. If you choose to do this, you need not determine the area or mass, and you should not place the backing sheet on the acetate after the sampling period is over. However do as much as possible to protect the sticky surface from dust, etc. while transporting it back to school. Examine your acetate under the microscope. What types of particles do you see? Are the particles the same from each location? Do you suppose that the time of year makes any difference in what will be collected? What about weather conditions?

Clear Seal, which comes in 3" x 4", 4" x 5", or 10" x 12" sheets of acetate with adhesive on one side and backing, which is obtainable from J.K. Gill Company either in 9" x 12" sheets at $0.30 each or from an 18" roll at $2.25 per yard. The Dennison packages are available in most stationary stores at $0.25, $0.49, and $0.79 per package by sizes listed above.

The size of sheet you choose for each student will be largely determined by the sensitivity of the balances you have available and the length of time you wish to expose the sheets. Mass increases are small--in the vicinity of 0.01 grams in a 2 x 3 inch sheet after 24 hours of exposure. If your balances are not sufficiently sensitive, you may wish to increase either the size of the sheet, the length of the exposure, or both. Mass changes are extremely variable, dependent upon location, weather, time of year, manner in which the acetate is mounted, etc.

Mounting of sheets for collection purposes can be done in any number of ways. A simple and satisfactory technique is to mount the acetate to walls or solid structures by simply using a loop of masking tape on the back surface. However it has been found that two factors are critical The first of these is whether the acetate is mounted horizontally or vertically, and the second is the direction (if mounted vertically) that the acetate faces. If you desire to have students use their results for comparison purposes, these two factors should be standardized for each class. Extremely interesting results have been found by using another collection method. This consists of having students mount 5 sheets of acetate on a square or rectangular block of wood, placing one sheet on each of the four sides and one on the top surface. A student should then be able to determine the dependence of the collection upon orientation of the acetate at a single location.

Better results seem to be produced when the students mass both the acetate and the backing sheet each time they make a measurement.

Under the microscope, students will be able to observe a large variety of sizes and shapes of particles that were captured. It may be interesting (and a good review) to have students determine the approximate diameter of some of the various particles.

A rough map of the area where the sheets were placed with the measured particulate collection (in grams/cm^2) placed on it may prove of interest. If there is large variation, students may be interested in attempting to explain the variation by location.

Part 2: GASEOUS MATTER

In order to examine some gaseous pollutants, we need to use a suitable source. Since most of these are emitted as a result of burning, a cigarette might be a convenient source. Under the direction of your teacher, assemble a smoking machine. Sample the smoke with the detector tubes and syringe (your teacher will explain their operation), and determine the presence and/or concentration of carbon monoxide and any other gaseous pollutants for which you have detection tubes.

Rough measurements can be made with the sampling pump using either the "length of stain" type or "color intensity" type of detector tube. Read carefully the instruction sheet packed with your tubes, being particularly careful to note which end of the detector tube is attached to the sampling pump, the volume of air to be sampled, the length of sampling time, the length of the reagent development (waiting) time, and the method of interpreting results. Probably the two most critical steps will be attaching the correct end of the tube to the pump and the length of sampling time. Several dry practice runs should be made with the pump, to insure that the air to be sampled is drawn into the

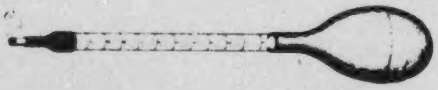
Part II: Gaseous Matter (Answers to Student Guide Questions:)

The T.L.V. (Threshold Limit Value for daily 8 hours exposure) is 50 ppm for CO. When it enters the bloodstream, it replaces the oxygen needed for the body's metabolism. At high concentrations it can kill quickly; at low concentrations it can bring on headaches and a slowing of physical and mental activity. Inside an automobile operating in heavy traffic, CO concentrations can reach high enough levels to affect the driver, thereby creating a possible safety hazard. At approximately 100 ppm most people experience dizziness, headache, lassitude, and other symptoms of poisoning. The California Department of Public Health indicated that an exposure to 30 ppm for 8 hours or to 120 ppm for one hour may be a serious risk to the health of a sensitive person.

The gaseous pollutants usually produced as a result of burning are carbon monoxide, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon dioxide. If students decide to check auto exhausts, etc. caution them against checking in an enclosed space or getting their face too close to the exhaust pipe or other source.

Construct smoking machines of either your own design or some other favorite design (there are directions for building 6 different easily constructed machines in the Health Service Publication

No. 1843--Smoking and Health Experiments, Demonstrations, and Exhibits). A complete commercial smoking machine kit (No. PL-1050) is available from Eduquip, Inc. (1220 Adams Street, Boston, Massachusetts 02124) at $19.95. For purposes of this experiment, where only a source of smoke is required, many teachers have found that a satisfactory smoking device can be constructed from a pipette with rubber bulb. A length of rubber tubing that will securely accept cigarettes (0.6 cm. inside diameter will suffice for most types) is placed over the end of the pipette. Adequate smoking of the cigarettes is obtained by manipulating the bulb at the desired rate. Smoke sampling can be accomplished either at the cigarette end or within the pipette (by removing the bulb), but it will probably be found that the concentration within the pipette will be too high to give any useful results with our equipment.*



The commercial machine and some of those described in the pamphlet provide filters (usually cotton or filter paper) for capturing tars, etc. Whether or not you wish to investigate or make mention of this aspect of the work is strictly teacher option.

pump at the proper rate (regulated by the rate at which the piston is withdrawn). If the air is allowed to enter too rapidly, gross errors will result!

When taking the sample, draw the piston back at the proper rate until the desired volume is achieved. If this volume can be reached without having to make more than one pump stroke, the detector tube should be removed as soon as the desired volume is reached. If more than one pump stroke is necessary, the exhaust vent should be used. Just before beginning the exhaust stroke, the rubber tube should be pinched off between the exhaust vent and the detector tube, and the tubing bent in such a manner as to provide as large an opening as possible for the exhausting gases. When all the air has been exhausted and the operator is ready for another intake stroke, the tube should be released and allowed to straighten out.

After the detector tube has had the proper volume of air drawn through it, the detector tube should be removed and the proper waiting time observed. Then either the "length of stain" or "color of stain" is matched against the calibration chart packed with each package of tubes in order to determine the concentration. If you are using "color intensity" type tubes

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**Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 at $0.20 each.*

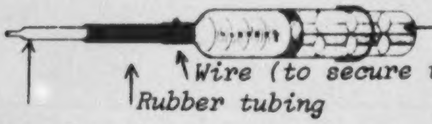
and find that the test area staining is not uniform, compare colors by using the end of the stained area most removed from the source.

If different groups use different types of cigarettes, (filter, non-filter, etc.), it might be interesting to compare results. How do the measured concentrations compare with acceptable standards? Do you suppose other burning operations, like those in an automobile engine, will produce similar results? How might you check?

Smoke from the cigarettes is tested for the presence and concentration of gaseous pollutants by the use of gas detector tubes. Tubes designed for use in testing for the presence and concentration of a large number of different gases (as well as some vapors, dusts, fumes, and mists) are available from Unico Environmental Instruments, Inc. (150 Cove St., Fall River, Massachusetts, or through Sanderson Safety Supply Company, 800 S.E. Hawthorne Blvd., Portland, Oregon 97214), Mine Safety Appliances Company (201 North Braddock Ave., Pittsburgh, Pa. 15208 or 5967 4th Ave. South, Seattle, Washington 98108), and Eduquip, Inc. (1220 Adams Street, Boston, Massachusetts 02124).

Even though a large number of pollutants can be found in cigarette smoke, you may wish to work only with one due to the cost of the detector tubes and the time involved. Carbon monoxide would be most highly recommended, both because of its familiarity to the students and the adaptibility of the unused tubes for use in the individual project work to follow, such as checking auto exhausts, etc.

Sampling pumps may either be constructed or purchased from the same sources as listed for the detector tubes. Due to the expense involved, most teachers choose to construct pumps of their own. A satisfactory pump can be produced by using a plastic syringe of any volume, even though 100 cm^3 would be most desirable. Most schools already have some of these, which are used in either IPS or Project Physics laboratory experiments. If the volume of the syringe is 100 cm^3 or more, simply attach a length of rubber tubing that will accept the glass detector tubes (0.4 or 0.5 cm inside diameter tubing will work for most). A short piece of wire may be needed to secure the tubing to the syringe. If the volume of the syringe is less than 100 cm^3, an exhaust opening should be cut into the rubber tubing between the tip of the syringe and the end of the glass detector tube. The exhaust opening is most easily produced by using a razor blade and cutting a slit through approximately one-half the diameter of the tubing.


Exhaust opening (if syringe is less than 100 cm^3.)
Piston
Wire (to secure tubing to syringe)
Rubber tubing
Gas detector tube

Special safety precautions must be taken when students are breaking the tips off of the ends of the glass detector tubes prior to their use with the air sampling pump. Without proper caution, glass cuts can result. Some manufacturers provide small rubber tips to aid in breaking off the ends, but others provide nothing. You may want to design some tube "breakers" for your students. A small piece of metal with an appropriate size hole (0.3 cm. is adequate) drilled into it will serve *nicely. Students should always have their hand protected (by toweling, handkerchief, etc.) and exert pressure close to the area where the break should occur. They should break the tubes as close to the narrow diameter ends as possible.*

The type of testing to be done is up to you, but you should remember that the student results are going to be very crude if they use syringes as sampling pumps and that conditions are not adequately controlled to make ***legitimate*** *comparisons of data from different cigarettes, etc. The following are some suggestions (listed for CO only, but they could be used for any other pollutant or combination of pollutants):*

1. Test for CO concentration in different brands of cigarettes.

2. Test for CO concentration in the same cigarette as its length decreases.

3. Test for CO concentration in a variety of types--i.e. regular, king and filter of the same brand.

4. Test for CO concentration of smoke that has and has not gone through a filter in the same cigarette.

If results are of the usual type, expect to find concentrations of CO in the vicinity of 500-1000 ppm when measurements are taken near the tip of the burning cigarette. The syringe type of pump tends to give results that are somewhat higher than those obtained by using professional equipment, dependent largely upon the skill of the student in manipulating the piston, which controls the rate *of flow of the air to be tested. If measurements are to be made right at the tip of the burning cigarette, it is recommended that it be allowed to burn at its natural (non-pumped) rate, due to the high concentration. You may even wish to have students make their measurements at set distances (10 cm, 20 cm, etc.) from the tip of the cigarette, which will probably prevent obtaining concentrations too high for your tubes to properly measure. If the color of the stained area in the detector tube is darker than the highest concentration's color on your chart, your measurements will not be of much value to students. Correct this by taking some of the corrective actions that have been listed above.*

If at all possible, each school should attempt to obtain at least one commercially manufactured precision air sampling pump, which will accurately control both the volume of air sampled and the rate of air flow during a test. This would allow interested students to do high quality quantitative work during the individual projects phase of the unit. Both Unico Environmental Instruments Inc. and Mine Safety Appliance Company offer these in the $50-100 category.

TEXT SECTION	ROUGH TIME ESTIMATES	EXPERIMENTS	DEMONSTRATIONS	TEACHING AIDS	OTHER STUDENT ACTIVITIES	OUTSIDE READING	PROBLEMS
Chapter V: Where Do We Go From Here?	1 Day						
A. Governmental Action				Excellent place to bring in an outside speaker or panel.	HDL 47,55		7,18
B. Individual Price							5,6,18,29

Chapter V: WHERE DO WE GO FROM HERE?

Now that we have examined two major types of pollution in some detail and have become aware of the many other types that exist, you may wonder what has been done and what is being done to combat pollution. Interest in environmental problems and pollution in particular is probably at an all time high for this nation. We are confronted with articles in literally every issue of the daily newspapers, in leading periodicals, and in public meetings of all sorts. Television keeps us posted through news, public opinion programs, and various specials that are produced dealing with the pollution problem. Politically, it appears that problems dealing with the environment may be one of the major issues in election campaigns in years to come. With increased student interest and concern, colleges and universities are rapidly adding courses and courses of study dealing with environmental problems and related occupational activities. In organizations of various types, such as SCOPE (Student Council on Pollution and the Environment), active steps are being taken to show the nation's concern about its environment.

A. GOVERNMENT ACTION

Many communities have created agencies to deal with various aspects of environmental problems. County, state, regional, and federal agencies are forming rapidly as new emphases arise. In many cases, laws have been developed to back up the operation of these agencies, particularly in the aspect of enforcement of regulations. It should be remembered that before any agency, committee, etc. can make intelligent decisions concerning pollution standards, control, or other related items, scientific studies must be made to determine the undesirable substances, how they are created and released into the environment, how they may be detected, what effect, if any, they have on the environment, and how their release may best be controlled. Legislation is providing funds so that this type of information can be determined by qualified persons.

Most knowledgeable people agree, however, that today we do not have enough information concerning man's effects upon the natural ecosystems, and that ecological management is probably best implemented as a flexible "trial-and-error" approach based upon the best available information and modified as new knowledge is obtained. It may take decades to accomplish the necessary research on ecological problems, due to the length of some life cycles and long-term genetic or other effects that cannot be adequately studied in a short-term period.

Most people tend to feel that the local governments are the first line of defense in the battle against pollution, and that often informed public pressure is the only way to get effective action at this level. Each citizen then should take it upon himself to become well informed about the welfare of our environment. He should support strong actions and legislation and insist that weak steps be strengthened. It should not be forgotten that pollution control costs money. These costs are ultimately shared by everyone, since they show up in larger taxes, increased production costs, and increased consumer costs, and a variety of other ways. However, a look at the positive side shows it also results in decreased cleaning bills, doctor bills, and other costs. The net cost may be zero.

B. INDIVIDUAL PRICE.

As our population continues to increase, individual freedom as we now know it may have to be curtailed in order to help control pollution. It is conceivable that in the future

See "Frontier Freedoms and Space Age Cities" by C.W. Griffin Jr. in the Feb. 7, 1970 issue of Saturday Review. The article is taken from a book of the same name, published by Pitman Publishing Company.

it may be necessary to declare restrictions on an individual's rights for the good of the public. Limits might be set on:

(1) Owning and/or operating an internal combustion engine powered automobile.

(2) Use of fireplaces in dwellings.

(3) Size of families.

Are you ready to pay the price, both dollar-and-cent-wise and activity-wise, that will be necessary within your lifetime? We must not seek to deny unpleasant truths about socially supported habits or institutions. Are you familiar with the laws regarding pollution that are now in effect in your city, county, state, region, and nation? Are you knowledgeable about the legislation that is now under consideration at these various governmental levels? It may all be affecting you more than anyone else around. Can you afford not to be informed and involved?

EPILOGUE

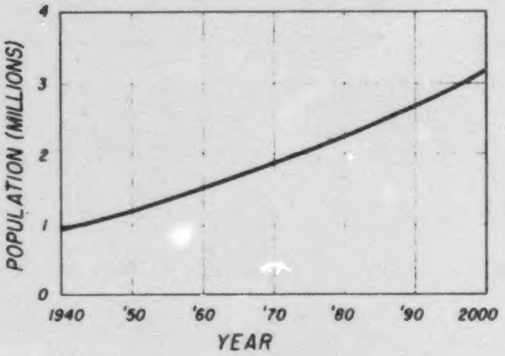
Our studies have indicated that change accompanies living organisms. As the earth experiences an increase in its human population density, certain changes in environmental relationships will have to occur if it is to maintain this increased population. The changes in environmental relationships may be the result of the need to produce more food, to find more living space, to dispose of more waste, or any one of many other factors.

It appears then that the real key to our future may be the intelligent planning and implementation of necessary changes so that we can maintain environmental balance. It is unrealistic to assume that we can increase both the population and the standard of living of that population and maintain current environmental relationships. It is equally unrealistic to attempt to bring our environment to the status it had 100 or more years ago. Our challenge appears to be this: to maintain an environmental balance which will allow us to absorb reasonable increases in population and still not disrupt matter and energy cycles and other sometimes delicate balances that exist between the many diverse things here on earth.

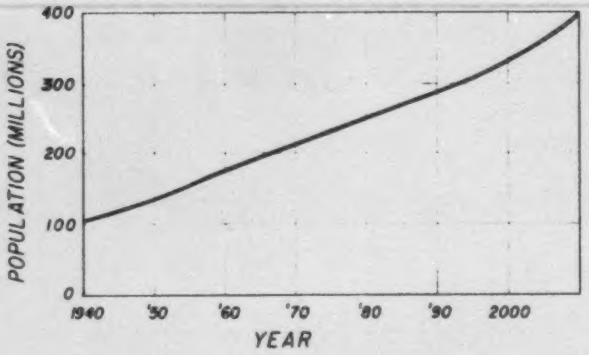
Teachers may wish at this time to discuss Oregon, United States, and World Population growth and growth predictions (based upon current trends and no significant population control programs).

This portion of your course has alerted you about the environmental challenge that we will all face as we look to the future.

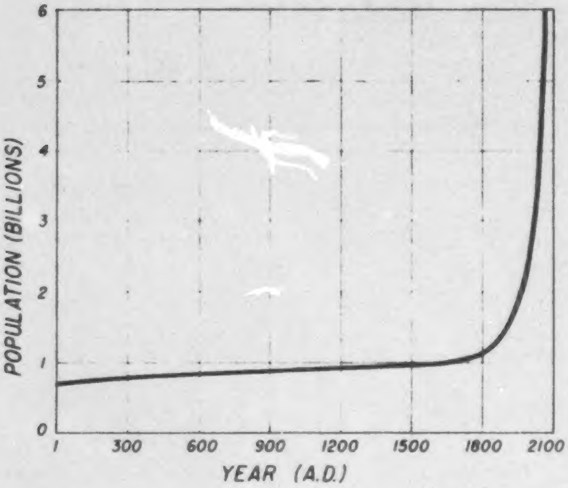
OREGON POPULATION



UNITED STATES POPULATION



WORLD POPULATION



Summary Chart for HDL

Type of Pollution	*HDL Activity*	*HDL Problem or Question*
Aesthetic	*8, 32, 47, 55*	*1*
Air	*8, 32, 35, 36, 37, 41, 42, 43, 47, 55*	*5, 6, 9, 13, 15, 30, 33, 38, 44, 50, 51, 53*
Chemical	*8, 32, 47, 55*	*44, 51*
Food	*8, 32, 47, 55*	*38, 44, 51*
Heat	*8, 32, 47, 55*	*3*
Mental	*8, 32, 55*	
Petroleum Products	*8, 32, 47, 55*	*22, 25, 26*
Population	*8, 32, 55*	*18, 28, 29*
Radioactive	*8, 32, 47, 55*	*11*
Soil	*8, 26, 32, 47, 54, 55*	*21, 23, 25, 44, 51*
Solid Waste	*8, 10, 32, 46, 47, 54, 55*	*7, 12, 23, 27*
Sound	*8, 32, 47, 55*	*33*
Space (Moon)		*31*
Water	*8, 26, 32, 40, 45, 47, 48, 55*	*1, 2, 4, 14, 16, 17, 19, 20, 21, 22, 24, 25, 34, 38, 39, 44, 49, 51, 52*

**Certain HDL's are designed to be thought-provoking in nature and do not have readily available sources from which answers may be obtained. If these HDL's, designated by underscoring in the chart above, are used, students should be alerted.*

EXERCISES FOR HOME, DESK AND LAB (HDL)

(1) A member of the staff of the Pacific Northwest Water Laboratory in Corvallis is reported to have said that two of the clearest lakes in the world are right here in Oregon. What do you suppose the two are?	*(1) Crater Lake and Waldo Lake. The other two in the top four are Lake Tahoe (California-Nevada) and Lake Baikal (Russia).*
(2) Biologists report that every lake is ephemeral or born to die. Some apparently last 10,000 years or more under natural conditions, but with man's help they may die within 200 or 300 years. (Lake Erie is often used as an example of a lake that has been speeded on its way to extinction.) Crater Lake and Waldo Lake are in the first stage (oligotrophic) in the life cycle. Recently a paved road was built to Waldo Lake and expansive recreational facilities added (it had been little used for recreation up to this time). What effect might the road and campgrounds have upon the lake?	*(2) Pollution and contamination of Waldo Lake may occur because of campground latrines and a trailer dumping station. Some problems may result from increased operation of motor boats and increased litter.*
(3) One aspect of logging operations effect on the environment that is frequently overlooked is the potential for producing heat pollution of some streams. How do you think some logging operations might cause this?	*(3) Trees are logged along the banks of the streams, thereby exposing the water to the sun for longer periods of time.*
(4) Logging operations have varying effects on the environment. Water quality can be affected in several ways--what do you think some of these may be?	*(4) Debris in streams, turbidity from sediment (most serious problem), heat pollution, and organic debris (changing the plant nutrient levels), resulting in algae and slime growths.*

(5) $20-25 per year (National average is $65). Expect to pay this amount for damage to crops, animals, cars, houses, nylons and other clothing, not to mention the possible damage to health and aesthetic values which cannot be measured. Sources: automobiles (10%), residential burning (10%), residential heating (10%), agricultural operations, including field burning (30%), and industry (40%).

(6) Cars may be operated by steam, batteries, turbines, natural gas, propane, or some other exotic power sources.

(7) $23 (as opposed to $16 in 1968).

(5) Newberg, Oregon is a small community located about 25 miles west of Portland. An air pollution official recently made an estimate of the cost of air pollution damage over a one year period to the average resident. What do you suppose it was? In what ways is this incurred? What do you suppose the sources of the air pollution are?

(6) Since the automobile is blamed for 50% or more of the nation's air pollution, many people predict the eventual abolition of the internal combustion engine for automobiles. What alternatives are there?

(7) Current Oregon law provides for a maximum fine of $500 for those convicted of littering, and the judge may sentence a violator to pick up litter rather than pay a fine. What do you suppose the average fine for littering was in 1969?

(8) Have your small group, class, or group of classes construct an environmental survey map of your community. Pinpoint sources of the various types of pollutants as well as locations of treatment facilities, water supplies, sanitary landfills, etc. It might be posted so that everyone in the school could observe it. If maps are available from other years, it might be

interesting to put yours beside some of them so we might observe changes that are taking place.

(9) One of the worst pollution associated disasters was the 1952 London "Great Smog." It was caused by smoke from countless open coal fires in private households, industrial smoke, and weather conditions. It prompted much anti-air pollution legislation. In seven days, the deaths attributed to this "Great Smog" were large in number. How many do you suppose?

(9) 4000. Public Health Service Publication No. 1556, "The Effects of Air Pollution," has a nice discussion of the various disasters.

(10) One answer to the problem of solid waste disposal is recycling the waste material into usable products. Old and abandoned auto bodies have presented a major problem. One solution to this particular problem is the use of an auto shredder, which converts the auto into metal bits usable as scrap metal. If there is one in your area, you might visit the location and observe its operation. It might also be of interest to inquire as to the disposition of the scrap metal.

(11) In a recent "Letter to the Editor" in a Portland paper, a citizen suggested a unique method of disposing of unusable, non-destructable nuclear and other wastes. He suggests loading the waste into missiles and firing them into the sun. What do you think about this?

(11) See the Oregon Journal, February 20, 1970 for the letter.

(12) 4.5 lbs estimated to go to 6 lbs. per person per day by 1980.	(12) About how many pounds of solid waste per person per day do you suppose we accumulate?
(13) Simply free air that is outside buildings.	(13) A frequently used expression in discussion of air pollution emission standards is "ambient air." To what does it refer?
(14) It may settle to the stream bottom and smother the aquatic environment, damaging spawning areas. The sedimentation can cause excess turbidity, which may result in death of adult fish, impairment of migration, death of eggs and larvae, increased vulnerability of fish to disease and predation, and reduction of fish food supply.	(14) A controversy in southern Oregon has been widely publicized. The controversy centers around silt in the Rogue River which is produced by placer mining. Many contend that it can ruin the salmon and steelhead runs in the famous fishing river. In what ways do you think the silt might affect the fish?
(15) The heat and upward air currents from a city may act much like a mountain range, forcing clouds to release their moisture by pushing them upward into thinner, cooler layers of the atmosphere. It is also suspected that cities may at times generate enough dust particles to produce an effect similar to cloud seeding.	(15) Scientists have recently suspected that in addition to producing smoke, noise, people, frayed nerves, etc. that cities may also be producing snow. This is particularly being studied in the area surrounding Lake Erie, where large localized snow falls are relatively common. How might a city produce snow?
(16) Possibly as much as 4.5 million gallons per minute, which would mean that an amount of water equivalent in volume to all of that in the bay would pass through the plants in less than a month.	(16) Nuclear powered power plants require water for cooling purposes. In Florida, two such power plants now under construction will use cooling water withdrawn from Biscayne Bay. How many gallons per minute do you suppose they are expected to need for operation?

(17) Many cities now have or have had sewer systems where during wet weather storm and sanitary sewers become combined. This results in raw sewage and other wastes, as well as the storm water, being directly discharged into rivers without any treatment. Does your city or sanitary district have this problem? If so, what can be done to correct it? Is it being done?

(17) Separated systems can be developed, where one system (sanitary) carries only sewage and another (storm) takes care of the water from rain or melting snow.

(18) What legislation has been passed or is being considered on a state or national level that is related to population control? Do you feel it is necessary to legislate in this area? Why?

(19) The State of Washington Water Pollution Control Commission recently reported the number of pollution caused fish kills for 1969. Try to find out the number of cases on record and the number of fish involved.

(19) 16 cases involving 140,000 fish in 1969, compared to 8 cases and 85,000 fish in 1968. Largest single kill of 1969 resulted in the death of 45,000 fish due to chlorine discharged into a river.

(20) A recently completed study by a variety of state and federal agencies recommended the construction of some water storage reservoirs in the Willamette Valley. These were proposed to meet the water needs of the area by the year 2020. How many do you suppose they recommended be constructed?

(20) 91, with 55 needed in the next 10-15 years and an additional 36 by the year 2020.

(21) Increased price of meat and meat products.

In recent years the total sewage wastes from feeder lots, in the U.S., have been greater than the total sewage wastes in our cities.

(21) Increased food demands have led to the industrialization of agriculture, with more animals being kept in smaller spaces, as evidenced by confinement pens and feeder systems. Animal sewage wastes from these are reaching momumental proportions. If sewage disposal plants have to be built to handle these animal wastes, what effect, if any, do you think this would have on the consumer?

(22) 10,000 birds. Fish forage underneath the surface, and since oil is immicible with water, they are not directly affected. Many birds, however, feed on top of the water where the oil congregates.

(22) During the last several years oil discharged into waters, particularly the ocean, has gained considerable attention. A recently discovered ocean oil slick in Alaska touched upon 1000 miles of shoreline and spread 200 miles out to sea. Effects here have been limited primarily to birds, but there is speculation that some other forms of ocean life may have also been affected. Officials have estimated that 10,000 birds may have been killed. Why do you suppose birds would be affected more than fish or mammals?

(23) They could be cut up and used for asphalt, landfill, or fuel.

(23) Old automobile tires present a particular problem. If buried, they won't deteriorate and if ground water is present, they may work their way to the surface, creating a spongy land fill. If burned, air pollution results. What might be done with them?

(24) A recently completed Oregon Water Study forecasts when Oregon will become a "water short" state. Do you know when this is predicted? What could be done to supplement the supply when this happens?

(24) 2020. Possibilities include the importing of water from Canada or elsewhere and the desalination of ocean water.

(25) Waste oil is a major problem in many areas. While properly operated municipal waste treatment facilities can normally cope with limited amounts of oil, the limit can easily be exceeded. A presidential report indicates some 350 million gallons of used motor oil must be disposed of annually by the more than 210,000 gasoline filling stations in the United States. What might be a solution to this problem? How well is your local sewage treatment plant prepared to handle waste oil?

(25) Waste oil reclamation and disposal plants must be built. A $600,000 one is proposed for Portland, which would be capable of receiving one million to more than 3.5 million gallons of slop oil. Some of the wastes could be reclaimed and sold as lubricating oils, while others could be used as fuels to burn at 500 gallons an hour in high-temperature thermal destructors, which would meet all air pollution regulations.

(26) Waste oils and related products are major pollutants in some areas. In the Portland area, for example, there are numerous sources of these pollutants. Identify as many as you can.

(26) Sludge oil pumped from tanker and cargo ships, waste oils from petroleum-oriented industrial plants, waste oil from firms that clean oil barrels, service stations and others that utilize lubricating oils in their operations, companies that clean cargo holds and ballast tanks, railroads disposing of wastes from tank cars, etc. Careless shipping practices account for most of the river contaminations, according to local experts. An oil tanker accident(for instance, hitting a bridge pier, etc.) could prove disastrous.

(27) Some people are recommending a "burial fee" be imposed upon each new car sale, to help take care of the cost of disposal. Others are recommending taxing gasoline or other consumables in order to have sufficient funds to handle disposal. Some people bury car bodies, while others grind them up for scrap metal. Some use has been made as material for jetty construction, dams, etc.

(28) Higher standard of living, with automobiles, freeways, extensive central heating, man-made fibers, etc.

(29) 70 years (and then the population would level off at a population greater than the current 200 million) Why? Because 30% of the population is 15 years of age or younger now.

(30) 1,473,817 (1969)

(27) The disposition of abandoned and/or worn out automobile bodies is a significant solid waste disposal problem, both in terms of cost and ultimate disposition. What might be some solutions?

(28) Dr. John H. Hessel, Stanford University sociologist, is reported to have stated that in terms of impact upon nonrenewable natural resources, the United States is the most overpopulated nation in the world. He indicated that in terms of ecological impact, each person in this country is the equivalent of 50 persons in India, 300 persons in Indonesia, and 3 persons in West Germany. What factors have prompted these rather surprising results?

(29) There is a big demand by some people for population controls at this time. It has been suggested that if American families adopt a policy of simple replacement, the population would not become stabilized immediately. How long do you suppose Hessel thinks it would take?

(30) Vehicles powered by internal combustion engines are the single largest source of air pollution. How many such vehicles do you suppose we have in Oregon at the present time?

(31) Man's recent visits to the moon have presented some rather unusual considerations regarding pollution. Much has been said and many concerns have been expressed about what might be brought back from the moon to contaminate the earth, but what about the other point of view? What might we be doing to the moon? List as many changes as you can that man's visits have produced in the moon's environment.

(32) Make a visit to a plant or factory using coal, gas, wood, or oil as a fuel. Observe the variety of activities going on that might lead to contamination of the environment. List the activity and the change or changes that you think it might produce.

(33) Compose a list of the human activities you can think of that contribute to air pollution. How might those you listed be controlled?

(34) Compose a list of the human activities you can think of that contribute to water pollution. How might those you listed be controlled?

(35) Vehicle exhausts are a major source of air pollution in heavily populated areas. See if you can find any effects of the exhaust emissions on the rear end of any automobiles or on garages or parking lot walls. Do you notice any apparent effects of exhaust emissions on vegetation?

(31) Its thin atmosphere has been polluted. Bacteria and other organisms leaked out of each of the spacesuits at the rate of approximately 1,000 per minute. The moon was littered with boots, gloves, a TV camera, tools for gathering rock samples, a seismometer, and a reflector (for laser beam experiments). The braking rockets discharge about five tons of exhaust gases by one estimate, which would equal about 5% of the moon's total existing atmosphere. The lunar crafts also leaked some fuel as they sat on the moon. Shooting lunar modules from the moon's surface may have left water molecules also.

(32) Be sure that the students don't neglect such activities as the movement of the fuel to the factory.

(36) Some mechanics use exhaust analyzers when tuning engines. See if you can find someone who will explain their operation to you or let you read the instruction booklet, so that you may establish any possible relationship that may exist between a tuned engine and air pollutants emitted from the exhaust.

(37) Most people breathe in and out more than 20,000 times a day, taking in a greater mass of air than food. You may wish to check some of your classmates or yourself to see how close you come to the average. The vital capacity of the lungs is about 0.5 liters. If one liter of air has a mass of 1.2 grams, express the mass of air in grams taken in during a day. How does this compare with the amount of food and water you take in daily?

(38) How long can a person go without water? without food? without air?

(39) Newspaper articles often speak of sewage treatment in terms of primary, secondary, or tertiary. What processes are involved in each of these stages of treatment?

(38) Water. Commonly measured in hours.

Food. Commonly measured in days or weeks.

Air. Commonly measured in minutes.

(39) Primary treatment consists mainly of the screening or grinding out of large objects, as well as the settling or floating out of smaller suspended solids. It removes about 35% of the organic pollutants from the sewage wastes.

Secondary treatment consists of allowing bacteria to destroy organic wastes as well as chlorination of the water. This step results in

(40) You may be interested in taking a closer look at the water system in your community. The answers to the following questions should provide useful information. Where does your water come from? Do other communities use the same source? How is it transported to your area? What kind of treatment does it undergo before use? Where does this treatment take place? What are the uses of the water? Where does it go after use? What kind of post-use treatment does it undergo? Where does this take place? What is the final disposition of the water?

(41) You may wish to survey exhaust emissions from various types and/or models of automobiles using the detection equipment provided for the smoking machine experiment. You may be limited to testing for carbon monoxide, but check with your teacher to see if detection tubes are available for other pollutants. How do the emissions compare?

(42) It may be of interest to measure the carbon monoxide concentration at a specific location (such as an important intersection) at various times during the day. How does it vary? Does the variation appear to be related to traffic

the removal of about 90% of the organic pollutants from the sewage water.

Tertiary treatment consists of the removal of dissolved chemicals, such as salts, insecticides, phosphorus, etc.

density, weather conditions, time of day, or some other variable?

(43) Teacher Note. Instructions for use of the Power's Microringelmann are printed on the device. They may be obtained from Power, 330 West 42nd Street, New York, New York 10036 at $0.35 each.

(43) A survey of air quality at various locations in your community might produce some surprising results. The detection equipment used in the smoking machine experiment may be used for measuring carbon monoxide concentration or that of other gaseous pollutants, if the detection tubes are available. In addition, the shade or darkness of smoke from various stacks can be measured with a Power's Microringelmann. (See your teacher for these.)

(44) Pesticides that are not broken down rapidly by natural processes, thereby allowing them to enter food chains by various means. DDT is a good example.

(44) The expression "persistent pesticide" often comes up in current news articles and television commentary. What does it mean?

(45) If you can schedule a visit to a sewage treatment plant, take a tour and see how wastes are treated. Discuss with the supervisor the problems experienced, if any, because of particular types of wastes, such as oils, detergents, etc.

(46) If possible, schedule a visit to a sanitary landfill. Discuss with the supervisor the daily procedure and future plans for the site. It may also be of interest to find out where the solid wastes being disposed of have come from.

(47) Are you aware of your local, state, and federal pollution abatement laws and standards? If not, contact the appropriate agency or agencies and inquire.

(48) Make a survey of the water quality in your area, including ponds, rivers, etc. The tests that you will be able to make (dissolved oxygen content, bacteria counts, etc.) will depend upon the equipment available, your ingenuity, and time. Check with your teacher. Do you have pollution in any of the water? What are the types of pollutants discovered? If pollutants were found, what appears to be their source? Are laws or standards being violated at the source?

(49) How many gallons of liquids per day do you suppose the sanitary system removes (and treats) from the average residence in your area?

(50) Remembering that the density of gases is about 1/1000th that of most solids and liquids and that carbon monoxide gas is released into the atmosphere by most motor vehicles, how many pounds of carbon monoxide would you guess are released from 1000 operating automobiles in the Portland metropolitan area in one normal working day?

(49) An average daily figure is 160 gallons, which would produce an average monthly figure of 4800 gallons.

(50) About 4000 lbs./1000 operating cars would be a good estimate.

(51) Through the food chain.

(52) Pure water is a poor environment for aquatic life. Something of this type might be done to provide food for fish and more green plants to increase the oxygen content.

(53) Dr. Phillip Lee, assistant secretary for health under the Johnson administration says "The dust-caused diseases are the greatest single group of occupational diseases in the United States, both in terms of disability and compensation costs." The Social Security Administration receives more than 35,000 claims a year for emphysema (lung disease), one fifth of them originating from people who claim they caught the disease from exposure to dust while on-the-job. They also receive as many as 8,000 claims a year for disability due to tuberculosis and pneumoconiosis ("black lung" disease of the soft coal miner) of on-the-job origin.

The United Mine Workers estimates that 100,000 American coal miners have X ray evidence of pneumoconiosis. A cancer of the chest cavity (mesothelioma) also strikes asbestos workers and has caused as many as 75 deaths in the asbestos trade in the past five years.

A growing complaint is also loss of hearing due to excessive on-the-job noise.

Skin diseases from the chemical industry have been one of the most nagging occupational health problems in this country. It is estimated that 800,000 people suffer some form of occupationally caused dermatitis every year.

(51) A Canadian Province recently closed the hunting season on ducks, geese, and pheasants because of mercury contamination of the animals. How might these animals have become contaminated?

(52) The State of Idaho recently considered the planned polluting of some small alpine lakes located in a wilderness area. Why would something of this nature ever be considered?

(53) As most of us know, occupational diseases represent a major area of health concern in our highly industrialized society, possibly affecting as many as two million American workers every year. Find out which general types of occupational diseases are most pronounced both in terms of disability and compensation costs.

(54) Analyze what you throw away each day. How much of your trash is really reusable? Could it be recycled? What "disposables" could be replaced by (perhaps more inconvenient) "returnables" or "reusables"?

(55) Find out what agencies, if any, in your community, county, or state have programs to fight pollution. Examine their programs and attempt to evaluate them.